Cross-retaliation and International Dispute Settlement

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Abstract

Although politicians and the popular press often express the desire to link retaliation in trade agreements to non-trade issues, the WTO discourages and usually disallows cross-retaliation even among its own agreements. In this paper we analyze the welfare implications of cross-retaliation. We compare two different mechanisms in a two-country two-sector tariff-setting political-economy model with incomplete information. A country may temporarily raise trade barriers in response to political pressure and the extent of this pressure is private information. In a same-sector retaliation mechanism a safeguard action, or other limited violation of the international trade agreement, is punished by an equivalent suspension of concessions in the sector where the initial deviation takes place. In a linked, or cross-sector, retaliation mechanism retaliatory actions may be taken in another sector or agreement. We next consider less-than-equivalent suspensions of concessions whereby the probability of retaliation is less than unity. We then endogenize this probability and derive its optimal level separately for same- and cross-sector retaliation. We also consider the long-run viability of these self-enforcing trade agreements. We show that whether retaliation is certain or probabilistic a cross-sector retaliation mechanism can generate greater welfare and self-enforcement capability than a same-sector mechanism unless export-oriented political pressure in the cross-sector targeted for retaliation is high. Although cross-sector retaliation is usually welfare improving, there may be little additional benefit to extending retaliation to a different agreement.

Keywords: international agreements; issue linking; cross-retaliation; dispute settlement; trade agreements; World Trade Organization

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1 Introduction

Amid continual calls to link trade agreements to environmental policy, labour concerns, nuclear disarmament, and even the occasional whims of political leaders, the World Trade Organization (WTO) has remained steadfast in choosing a different tack. In particular, Article 22.3 of the WTO's dispute settlement understanding (DSU) generally opposes cross retaliation among its own international commerce agreements unless same-agreement retaliation is not viable.[1] In its own rulings it has only permitted cross-agreement retaliation in three out of the nineteen cases where retaliation has been sanctioned and it has only allowed it when there are stark differences in economic size and export composition between the complainant and defendant country.[2] On the other hand, the WTO is more permissive with respect to cross-sector retaliation within an agreement.[3] We take these stylized facts as our point of departure and analyze the WTO's reluctance to permit cross-agreement retaliation and its willingness to allow cross-sector retaliation and we provide conditions for linked agreements (allowing cross-sector, or cross-agreement, retaliation) to be preferable to unlinked agreements even for similar countries.

To investigate these issues we introduce multiple sectors into a two-country tariff-setting political economy framework where a country has private information about the varying level of domestic political pressure to restrict imports. When political pressure is high a government may wish to grant temporary protection to a domestic industry by raising import tariffs in a sensitive sector. Such temporary suspensions of concessions are provided for in the GATT Articles covering anti-dumping and countervailing duties, balance of payments crises, infant industry protection, import surges, health and safety, and national security.[4] These flexibility

[1] Article 22.3 paragraph (a) of the WTO's DSU stipulates that retaliation in the form of a suspension of a previously granted concession should occur in the same sector(s) whereby the violation took place. In DSU article 22.3 paragraph (b) it concedes that if same sector retaliation is not practicable, then cross-sector retaliation in the same agreement could be permitted. Paragraph (c) states that only if within agreement retaliation is not practicable or effective, and if the violation and its effects are highly serious, then cross-agreement retaliation may be considered. It should be noted that the WTO agreement and the DSU never use the word "retaliation" and instead refer to a suspension of concessions or other obligations. We use the word retaliation to indicate that same suspension of concessions.

[2] As of December 31, 2020 there have been 598 disputes initiated in the WTO. Some of these disputes are settled by the involved parties, so that panel reports were made in 265 of those cases and compliance panels to correct the dispute causing behavior have been established in 51 cases. In 37 such cases compliance was not considered adequate and arbitration to determine the allowable level of retaliation has begun and initial decisions have been made in 19 cases. Cross-agreement retaliation was permitted in the amount of $201.6 million US dollars per year in the EC – Bananas III case of Ecuador against the EC, $21 million per year in the US – Gambling case of Antigua and Barbuda against the US, and $147.3 million in the US – Upland cotton case of Brazil against the US. This last case was settled for a one time payment of $300 million to a Brazilian cotton industry institute.

[3] The WTO encompasses the general agreements on tariffs and trade (GATT), trade in services (GATS), trade related aspects of intellectual property (TRIPS), investment measures (TRIMS), the DSU, the annexes of the above agreements, and the plurilateral agreements on government procurement and civil aircraft. DSU Article 22.3 paragraph (g) does not include TRIMS as a covered agreement for cross-retaliation and Article 22.5 states that there can be no cross-retaliation if the other covered agreement does not allow for a suspension of concessions. Although TRIMS does not prohibit a suspension of concessions for any violation of the agreements, none of the TRIMS disputes have so far resulted in sanctions. In a recent case, however, the USA, as a complainant, has requested sanctions against India for their domestic content requirement in solar cells and has cited violation of the GATT, the subsidies and countervailing agreement and also TRIMS in their complaint.

[4] Article VI provides for anti-dumping and countervailing duties. Although this provision may, at first glance, appear to

provisions exist in order to maintain the viability of the trade agreement. Of course, their existence could invite abuse.

To prevent a government from continually claiming that political pressure for temporary protection is high the GATT, and its successor the WTO, allow for a reciprocal suspension of concessions by the trading partner. For example, article XIX paragraph (c) states that "the affected contracting party is free to suspend...substantially equivalent concessions or other obligations under this Agreement..."[5] In addition to these flexibility provisions a country may choose to temporarily violate, but not completely abrogate, the agreement by restricting imports without appealing to the above mentioned GATT articles. These violations often generate disputes which can be brought to the WTO's dispute settlement board (DSB). In settling these disputes Article 22.4 of the DSU states that "The level of the suspension of concessions or other obligations authorized by the DSB shall be equivalent to the level of the nullification or impairment."

Whether a country attempts to restrict imports through a flexibility provision or a limited temporary violation, the GATT/WTO is adamant in restricting retaliation to be no more than reciprocal. In fact, as Bagwell and Staiger [4] and Bagwell and Staiger [6] show, reciprocity (and non-discrimination) are the cornerstones of the efficient aspects of the GATT/WTO. In addition, the reciprocal removal of concessions is implicit in GATS Article XXI. It also has historical significance. Reciprocity was introduced in the (Anglo-French) Cobden-Chevalier Treaty of 1860 which is the first-known explicitly-written trade agreement.

We use the terms "escape valve" and "contingent protection" interchangeably to describe both flexibility provisions and temporary violations. We start by allowing for a temporary escape-valve tariff within a sector that is reciprocated with an equivalent tariff increase by the trading partner. We show that this schedule of reciprocal tariffs induces truthful revelation of the state of political pressure, so that no country has an incentive to misrepresent the true state.

The most important assumption in our framework is that tariffs are strategic substitutes within a sector, or agreement, and are strategically neutral across sectors or agreements. Without both incomplete information and strategic substitutability of tariffs there is no difference between same- and cross-sector retaliation. It is only when these two aspects are combined that these two mechanisms produce different outcomes. The information revelation mechanism we employ uses contingent protection whose cost to the country applying the temporary tariff increase is tied to its level. A larger escape-valve tariff implies larger retaliation.

sanction retaliation, its continual abuse has allowed it to serve as one of the main forms of temporary protection used by GATT signatories (see Prusa [31] and Blonigen and Prusa [12]). The remaining escape valves allow for balance of payments concerns (Article XII), infant industry protection in developing countries (XVIII), protection against import surges that damage domestic industries (XIX), health and safety reasons (XX), and national security (XXI).

[5] In addition to Article XIX, Articles XVIII, XIX, XX, and XXI all require an equivalent concession or reciprocity for the temporary withdrawal of any previous granted tariff concession.

Crucially, when tariffs are strategic substitutes, the benefit of the escape-valve tariff to the country using contingent protection is decreasing in the level of the trade partner's reciprocating tariff. For this reason, the size of the escape-valve tariff and the retaliatory tariff that it generates are lower when tariffs are strategic substitutes. Hence, the escape-valve tariff is larger in the cross-sector mechanism.

There are two reasons why allowing linked agreements and cross-sector, or cross-agreement, retaliation enhances world welfare in our framework. First, when one country raises its tariffs it creates a home-bias in consumption. A retaliatory tariff in the same sector exacerbates this home bias and, given the love of variety in consumption it is better to have a small home bias in each sector rather than a large bias in one sector. It is for this reason that same-sector tariffs are strategic substitutes and, therefore, why cross-sector retaliatory tariffs have a lower welfare cost. Second, the efficient (under perfect information) escape-valve tariff under high political pressure is larger than either the same- or cross-sector mechanism tariffs. Since the cross-sector escape-valve tariffs are larger they are closer to the information-unconstrained (and efficient) high-state tariffs.

We show that the degree of substitutability in consumption determines the level of strategic substitutability of tariffs and we use this parameter to also differentiate between cross-sector and cross-agreement retaliation. If there are sectors in the same agreement that are available for retaliation and that have little or no consumption relationship with the goods receiving the escape valve protection, then there is little value to extending the retaliation to cross-agreement. Since protection and retaliation takes differing forms in agreements covering intellectual property, services, and goods, there would be an additional cost to calculating equivalent retaliation in a different agreement. In this case, the WTO's decision to limit cross-agreement retaliation appears prudent.

Although (as noted above) the GATT/WTO allows for equivalent retaliation, this full reciprocity is excessively strict and generates slack in the incentive compatible constraints. We, therefore, consider weaker forms of reciprocity that still elicit truthful revelation of the level of political pressure. Although our main result would obtain with any retaliatory tariff that is an increasing function of the violation, we again look at GATT/WTO practice in developing this alternative mechanism. In particular, we consider the uncertainty in the dispute settlement process as the probability that a reciprocal temporary suspension of concessions to an applied escape valve will be authorized.[6] We show that cross-sector retaliation is still preferred whether this

[6] As seen in footnote 2, the probability of a WTO dispute eventually generating reciprocal sanctions is less than unity. Beshkar [10] and Beshkar [11] also demonstrate that reciprocal retaliation can be excessive and shows that a probability of less than one that the WTO correctly supports the complainant can improve welfare even when the retaliation is equivalent, but is randomly sanctioned. In a different framework than ours, Maggi and Staiger [29] also show that the optimal trade agreement does not fully compensate the complainant for their loss. An alternative approach to probabilistic retaliation would consider the time between when compliance is mandated and retaliation is sanctioned as generating less-than equivalent retaliation.

probability is given exogenously, and the same, for both same- and cross-sector agreements or endogenized and set optimally for each type of agreement.

An abrogation of the trade agreement occurs when a country ignores the negotiated tariffs and available contingent protection and sets unilaterally optimal tariffs in both sectors with the knowledge that all tariff concessions will be removed in all future periods. The ability of these non-abrogation or voluntary participation constraints to prevent a breakdown of the trade agreement depends in part on the sector of retaliation for the exercised escape valve. In particular, the future cost of violating the agreement is larger with cross-sector retaliation, therefore, cross-sector retaliation allows the agreement to remain viable for a greater range of parameter values and external shocks.

We also consider political pressure for the exportable goods that are subject to retaliation. If the export-good political pressure exists in both sectors, or only in the same sector as the high-state import-competing political pressure, then our results do not change. Of greater interest is when export-good political pressure only exists in the opposite sector to the import-competing pressure. In this case, limiting retaliation to the same agreement and even the same sector can generate greater welfare.

Although we focus on international trade between similar economies our model can also shed light on wider issues in international relations. For example, emissions of pollution that damage the global commons can be analyzed in a similar manner to an international trade agreement whereby the tariff violations would be replaced by the amount of pollution emitted by each country. Each country is assumed to have some benefit from polluting more (avoiding abatement costs) but they also suffer from global environmental damage, which is usually modeled as a convex function of the sum of the emission levels. If this damage function is strictly convex, then the choice variables are also strategic substitutes. To some extent international agreements covering nuclear non-proliferation, chemical weapons, cyber security and labour standards among others could also be analyzed by a variation of our framework. Hence, our results could be considered as more general than applying only to international trade agreements. Still, to address aspects of the WTO, as well as for analytical tractability, we proceed to describe an environment of two sectors of traded goods.[7]

For example, although the GATT Article XIX allows for immediate retaliation, the WTO Safeguards Agreement allows the safeguard to be applied for three years before reciprocal retaliation is permitted. Similarly, violations brought to the WTO DSB often require lengthy review processes. In this way, the probably parameter could serve as a combined measure of the discount factor for the time before retaliation is applied and the relative number of periods in which contingent protection occurs without retaliation. See Brewster [13] for information on this remedy gap.

[7] Of course, the parameters could differ across agreements. Furthermore, although it would not be optimal to use chemical weapons to retaliate against trade restrictions, trade restrictions might serve as a means of retaliating against the use of chemical weapons. We leave the analysis of optimal linking in asymmetric cases for future research.

2 Related Literature

The theoretical literature on cross-retaliation begins with Bernheim and Whinston [9] who show that linking punishments can increase cooperation, but only if there are asymmetries between the players and/or agreements (firms and markets in their industrial organization application). Spagnolo [32] shows that even if firms and markets are symmetric, there can be gains from linking if the firms' objective functions are strictly concave so that losing collusive payoffs in both markets is more than twice as costly in welfare terms as losing them in only one. Limao [24] extends Spagnolo [32] to linking trade and environmental agreements. If tariffs and pollution taxes are strategic complements, then deviating simultaneously in both agreements yields the deviating country less benefit than the sum of the gains from deviating in each policy independently. On the other hand, Ederington [17] demonstrates that linking can be harmful when countries incorrectly observe deviations, but it is beneficial if they fail to detect it. We add to this literature by introducing incomplete information and strategic substitutability of within-sector tariffs to show that there are enforcement and negotiation benefits to linking sectors, or agreements, even when countries and sectors (or agreements) are symmetric and there is no relationship between the sectors (or agreements).[8] For a comprehensive overview of the literature on linking international issues and agreements see Maggi [28].

Our model combines elements of a political economy model with incomplete information as in Bagwell and Staiger [7], Bagwell [8], Beshkar [10], and Beshkar [11] and of a multi-sector tariff setting model as in Chisik and Onder [15].

The GATT, which was originally signed in 1947 and succeeded by the creation of the WTO in 1995, makes no mention of cross-sector retaliation and, because it was a stand-alone agreement, does not consider cross-agreement retaliation. On the other hand, one of the first proposals in the creation of the WTO umbrella was for the suspension of concessions under the GATT for failure to comply with panel rulings under TRIPS.[9] As discussed by Abbott [1] and Subramanian and Watal [34], it was resistance by developing countries such as Argentina, Brazil, Chile, India, Nigeria and Peru to this form of cross-retaliation that generated the limitations to cross retaliation in the DSU Article 22.3. In the few cases where the WTO has sanctioned cross retaliation it has, however, only been permitted in the opposite direction: developing countries that were

[8] Chisik and Onder [15] also allow for reciprocal retaliation and show that cross-sector tariffs are higher. As there is perfect information and a constant absence of political pressure in their model, the non-fluctuating, lower, same-sector tariffs are preferred. In their perfect information framework, however, trade disputes never occur in equilibrium and reciprocal retaliation is inefficient. Given the inefficiency of proportional retaliation in their framework, the optimal probability of retaliation (if considered) would be one for both same- and cross-sector retaliation.

[9] In an early, October 1987, proposal to the group negotiating TRIPS, the US requested that "In the event that recommendations [of a dispute settlement panel] are not complied with, the agreement should provide for retaliation including the possibility of withdrawal of equivalent GATT concessions or obligations" (GATT [19]).

considered too small to positively affect their terms of trade were allowed to cross-retaliate (in agreements other than the GATT) against the EC and the US. We abstract from country size asymmetries to focus on how linkage affects the negotiated outcome and the enforcement capability of the agreement even when countries are of the same economic size.[10] In particular, we provide conditions for cross-retaliation to generate a more (or less) efficient tariff negotiation outcome and we also show that there may be little benefit to extending cross-sector to cross-agreement retaliation. Although we refer to agreements under the WTO our analysis would also apply to cross-retaliation in Preferential Trade Agreements (PTAs). While PTAs generally have fewer, or no, restrictions against, or guidelines with respect to, cross retaliation, they are still constrained by the fact that any action taken in a PTA among WTO members must also be consistent with their WTO obligations.

In the next section we describe the economic framework and analyze the perfect information outcome. In section 4 we compare same- and cross-sector retaliation. We consider probabilistic retaliation mechanisms in section 5 and analyze trade agreement abrogation in section 6. Export-good political pressure is analyzed in section 7 and our conclusions are contained in section 8.

3 Economic Environment

3.A Fundamentals

We analyze trade policy in the following environment. There are two countries, Home (no star) and Foreign (*), a numeraire good, denoted by z, and two additional sectors, defined as $i \in \{a, b\}$. In these two sectors there are two goods represented by $j_i \in \{x_i, y_i\}$. We may think of these as two sectors in the same agreement or sectors in two different agreements. For now the key distinction between sectors (or agreements) is that they are unrelated in consumption. In a later section we will modify the analysis to differentiate between sectors in the same agreement, which may exhibit some substitutability in consumption, and those in differing agreements, which are not substitutable. Each sector signifies a group of goods that are in a related category. These goods may have very similar Harmonized System (HS) codes, or they may be spread across several categories. For example, the US section 232 safeguard tariff on steel and aluminum imposed in 2018 covered numerous HS codes from 7206.10 through 7306.90 for steel and 7601 through 7616.99.51.70 for aluminum. The EU, Canada, and Mexico retaliated by levying tariffs against disparate US products such as bourbon whiskey (HS8 code 2208.30.60), Harley-Davidson motorcycles (HS6 code 8711.50), agricultural products, as

[10] Maggi [28] suggests that linkages can be evaluated on how they affect negotiation, enforcement, and participation outcomes. In our two-country framework, there is no participation issue other than the one subsumed under enforcement.

well as some steel products.[11] Our idea is that steel and aluminum products are goods in the same sector and distilled spirits are in a different sector.

Time is infinite and discrete (i.e. $t = 0, 1, ...$). Preferences of Home's consumers are represented by: $U(\cdot) = \sum_{t=0}^{\infty} \delta^t [\sum_{i=a,b} u_{it}(\cdot) + z_t]$, where $u_{it}(\cdot)$ and z_t are the home utility from sector i and the numeraire sector in period t, respectively, and $\delta < 1$ is the common factor by which consumers, firms and governments discount future consumption.

The sector i sub-utility, $u_{it}(\cdot,\cdot)$, takes the following quadratic form:

$$u_{it}(q^d_{x_it}, q^d_{y_it}) = \frac{1}{1-D^2}[A(1+D)(q^d_{x_it} + q^d_{y_it}) - \frac{1}{2}(q^d_{x_it})^2 - \frac{1}{2}(q^d_{y_it})^2 - Dq^d_{x_it}q^d_{y_it}], \tag{1}$$

where $q^d_{x_it}$ and $q^d_{y_it}$ are Home's consumption of goods x_i and y_i in period t, $A > 0$ is a taste parameter which measures the intensity of preferences (and it would also be the demand choke price if the goods are neither substitutes or complements), and $D \in (0, 1)$ indicates the extent of substitutability between the goods. Foreign preferences, denoted by $U^*(\cdot)$ and $u^*_{it}(\cdot)$ are given by identical expressions.

Labour (ℓ, ℓ^*), the only factor of production, is assumed sufficiently large so that there is positive numeraire production in both countries. The numeraire good is produced with the same constant-returns-to-scale technology in Home and Foreign and we can, therefore, normalize the price of the numeraire good and the wage to unity in both countries.

Technology for the sector a and sector b goods can be represented by the following aggregate cost functions:

$$\begin{aligned} C_{x_i}(q^s_{x_it}) &= \frac{(q^s_{x_it})^2}{2}; \quad C_{y_i}(q^s_{y_it}) = fq^s_{y_it} + \frac{(q^s_{y_it})^2}{2}. \\ C^*_{x_i}(q^{s^*}_{x_it}) &= fq^{s^*}_{x_it} + \frac{(q^{s^*}_{x_it})^2}{2}; \quad C^*_{y_i}(q^{s^*}_{y_it}) = \frac{(q^{s^*}_{y_it})^2}{2}; \end{aligned} \tag{2}$$

where $q^s_{j_it}$ and $q^{s^*}_{j_it}$ are the quantities supplied by Home and Foreign in period t, respectively, and $f \geq 1$ is an exogenous parameter. So that all quantities are positive we assume that $A > 2f$. Since $f > 0$, Home has a comparative advantage in, and is the natural exporter of, the x goods (x_a and x_b). Similarly, Foreign has a comparative advantage in y_a and y_b. There are a large, but fixed number of firms in each good in

[11] As a point of reference HS6 code 2208.30 is for all whiskeys, the HS8 code signifies bourbon, and the HS10 code signifies the size of the whiskey bottle. Using the US classification, baseballs (9506.69.2040) and softballs (9506.69.2080) share the same HS8 code, differing only at the HS10 level. On the other hand, inflatable balls such as basketballs (9506.62.8020) and soccer balls (9506.62.4080) only have the same HS6 code as each other and share only the same HS4 code with baseballs. The HS4 code 9506 includes all of the above balls, and other sporting equipment such as baseball bats and hockey sticks, but it also includes the less-related category of swimming and wading pools. All countries use the same HS6 classification introduced in 1998 (except for a few isolated cases where an old classification is still used) but HS8 and HS10 differ by country.

each sector. Although competitive, the lack of free entry allows for positive firm profits. Ownership of the firms that produce the goods is shared equally by the inhabitants of their country of production and these inhabitants use their share of the profits and their labour income to purchase goods.

In every period t, consumer maximization yields the following demand functions, where $p_{j_i t}$ is the equilibrium price of good j_i in Home:

$$q^d_{x_i t} = A - p_{x_i t} + D p_{y_i t}; \quad q^d_{y_i t} = A - p_{y_i t} + D p_{x_i t}. \tag{3}$$

Letting $p^*_{j_i t}$ denote prices in Foreign, the Foreign demand functions, $q^{d^*}_{j_i t}$, are similar to those in Home.

Profit maximization by the competitive firms generates the following Home and Foreign supply functions:

$$q^s_{x_i t} = p_{x_i t}; \quad q^s_{y_i t} = p_{y_i t} - f; \quad q^{s^*}_{x_i t} = p^*_{x_i t} - f; \quad q^{s^*}_{y_i t} = p^*_{y_i t}. \tag{4}$$

Each government chooses a sequence of per-unit tariffs, $\tau_i = \{\tau_{it}\}_{t=0}^{\infty}$ and $\tau_i^* = \{\tau^*_{it}\}_{t=0}^{\infty}$, to maximize their political welfare function.[12] The relationship between Home and Foreign prices is described by $p^*_{x_i t} = p_{x_i t} + \tau^*_{it}$ and $p_{y_i t} = p^*_{y_i t} + \tau_{it}$. Given that trade is balanced in equilibrium and using the demand and supply functions in equations (3) and (4), we have

$$p_{x_a t}(\tau^*_{at}) = \Psi - \frac{1}{2}\tau^*_{at}; \quad p_{y_a t}(\tau_{at}) = \Psi + \frac{1}{2}\tau_{at}; \quad p^*_{x_a t}(\tau^*_{at}) = \Psi + \frac{1}{2}\tau^*_{at}; \quad p^*_{y_a t}(\tau_{at}) = \Psi - \frac{1}{2}\tau_{at}, \tag{5}$$

where $\Psi = \frac{2A+f}{4-2D}$. We can then write the level of imports in Home and Foreign as:

$$M_{y_i t}(\tau_{it}, \tau^*_{it}) = \frac{f}{2} - \tau_{it} - \frac{D}{2}\tau^*_{it}; \quad M^*_{x_i t}(\tau_{it}, \tau^*_{it}) = \frac{f}{2} - \tau^*_{it} - \frac{D}{2}\tau_{it}. \tag{6}$$

Government preferences in Home, but not Foreign, assign an added value to the consumption that is provided by profits from the import competing industry in the a sector. This extra value appears as a weight, $\theta_{\kappa t} \geq 1$ (where $\kappa \in \{L, H\}$), on sector a import-competing profits in the Home government's indirect utility, or **political welfare**, function $\vartheta_a(\tau_{at}, \tau^*_{at}, \theta_{\kappa t})$ which is derived in equation (7) below. This political pressure may arise from rent-seeking lobbyists in the import competing sector or it may result from an honest application of the allowable reasons for contingent protection (provided in GATT articles VI, XII, XVIII, XIX, XX, and XXI) as noted in footnote 4. Of course, rent-seeking lobbyists are likely to claim many of these same reasons as justifications for their protection request.

We make the following assumptions about this political weight, $\theta_{\kappa t}$. First, to capture the idea that the

[12] Policy instruments in some agreements may not take the form of tariffs, however, we model the tariff equivalent. Still, we recognize that one limitation of cross-agreement retaliation is the calculation of equivalence. We abstract from this point in the current analysis.

government may face fluctuating political pressure, we allow $\theta_{\kappa t}$ to take two values, $\theta_{\kappa t} \in \{\theta_L, \theta_H\}$. High pressure is given by $\theta_H > 1$ and low pressure by $\theta_L = 1$. Second, the probability that it takes on either of these two values is independently and identically distributed and in every period $\theta_{\kappa t} = \theta_L$ with probability $1 - \lambda$ and $\theta_{\kappa t} = \theta_H$ with probability λ. Finally, we assume that $\theta_H < \bar{\theta} < 3$, where $\bar{\theta} > 1$ will be derived below.[13] Finally, we assume that this political pressure is private information of Home's government.

Political welfare is a weighted sum of the country's producer surplus, consumer surplus and tariff revenues in that period, where the sequence of weights on producer surplus, for good y, in sector a in Home is $\{\theta_{\kappa t}\}_{t=0}^{\infty}$.[14] The per-period political welfare of Home in sector a is defined as:

$$\begin{aligned}\vartheta_{at}(\tau_{at}, \tau_{at}^*, \theta_{\kappa t}) = & \int_{p_{x_a t}(\tau_{at}^*)}^{A} \int_{p_{y_a t}(\tau_{at})}^{A} u_{at}[q_{x_a t}^d, q_{y_a t}^d] dp_{y_a t} dp_{x_a t} \\ & + \int_0^{p_{x_a t}(\tau_{at}^*)} q_{x_a t}^s dp_{x_a t} + \theta_{\kappa t} \int_f^{p_{y_a t}(\tau_{at})} q_{y_a t}^s dp_{y_a t} + \tau_{at}[q_{y_a t}^d - q_{y_a t}^s],\end{aligned} \tag{7}$$

where the chosen quantities depend on the equilibrium prices from equation (5). The first term on the right-hand side of equation (7) is consumer surplus. The second and third terms are producer surplus and the fourth term is tariff revenue. Home sector b welfare and welfare in both Foreign sectors is the same as Home sector a except that the producer surplus weights are always 1. Home per-period political welfare can then be written as $V(\tau_{at}, \tau_{at}^*, \theta_{\kappa t}, \tau_{bt}, \tau_{bt}^*) = \vartheta_a(\tau_{at}, \tau_{at}^*, \theta_{\kappa t}) + \vartheta_b(\tau_{bt}, \tau_{bt}^*) + \ell$ and Foreign as $V^*(\tau_{at}, \tau_{at}^*, \tau_{bt}, \tau_{bt}^*) = \vartheta_a^*(\tau_{at}, \tau_{at}^*) + \vartheta_b^*(\tau_{bt}, \tau_{bt}^*) + \ell^*$. Denoting E as the expectation operator with respect to θ, Home's expected political welfare, before the state is revealed, is $EV(\tau_{at}, \tau_{at}^*, \theta_{\kappa t}, \tau_{bt}, \tau_{bt}^*)$ and the discounted sum of expected Home per-period value functions is $\sum_{t=0}^{\infty} \delta^t EV(\tau_{at}, \tau_{at}^*, \theta_{\kappa t}, \tau_{bt}, \tau_{bt}^*)$ with similar expressions for Foreign. Denoting $\Omega(\theta_{kt}) = V(\tau_{at}(\theta_{kt}), \tau_{at}^*(\theta_{kt}), \theta_{\kappa t}, \tau_{bt}(\theta_{kt}), \tau_{bt}^*(\theta_{kt})) + V^*(\tau_{at}(\theta_{kt}), \tau_{at}^*(\theta_{kt}), \tau_{bt}(\theta_{kt}), \tau_{bt}^*(\theta_{kt}))$, we then can write the per-period expectation of world political welfare as $E\Omega(\theta) = \lambda\Omega(\theta_H) + (1-\lambda)\Omega(\theta_L)$. In contrast

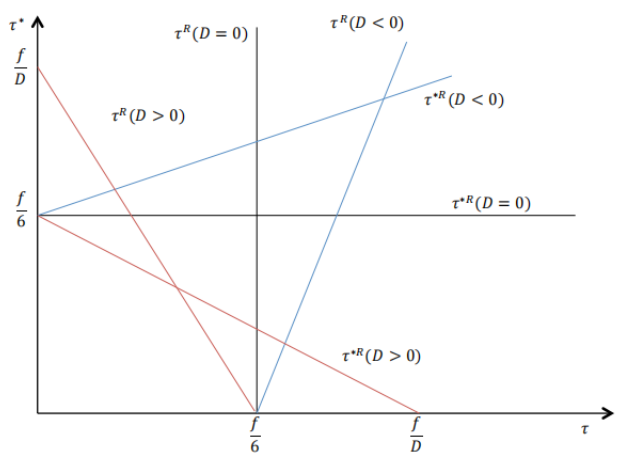
[13] The critical $\bar{\theta}$ will guarantee three things. First, it will preclude autarky. Second, it will ensure that Foreign will fully use the allowed reciprocal retaliation. Third, when we look for the optimal probability of reciprocal retaliation, the upper bound will guarantee that the roots of the quadratic equation that determines these optimal probabilities do not contain an imaginary part. We can rank these critical upper bounds for θ_H. Whereas the one that prevents autarkic tariffs is the largest, whether the one that rules out imaginary roots or the one that engenders full reciprocal retaliation in the probabilistic case is lower depends on the probability of retaliation. We denote $\bar{\theta}^{NI}(A, f, D)$ as the upper bound for θ_H that precludes imaginary roots and $\bar{\theta}^{FR}(A, f, D, \gamma)$ as the one that engenders full reciprocal retaliation, where γ is the probability of retaliation. Hence, we take $\bar{\theta} = min\{\bar{\theta}^{NI}(A, f, D), \bar{\theta}^{FR}(A, f, D, \gamma)\}$. We report these critical upper bounds for θ_H in footnote 21 for the deterministic retaliation case, footnote 22 for the probabilistic retaliation case, and in the online appendix for the optimal probability of retaliation case. All of these upper bounds are greater than unity and are decreasing in A and D, therefore, when A approaches $2f$ and D approaches 0, $\bar{\theta}^{NI}(A, f, D)$ approaches its supremum of 25/9 and $\bar{\theta}^{FR}(A, f, D, \gamma)$ approaches $2+\gamma$. Hence, we assume that $\theta_H < \bar{\theta} < 3$ to cover all of the necessary cases.

[14] Magee, Brock and Young [26] provide the earliest micro-foundation for the above politically weighted measure of welfare. In their framework two parties compete in an election and a third party, known as the "lobby groups", makes campaign contributions to the political parties. In order to gain support and win the election, the two competing parties commit to trade policies that only benefit the lobby group. In Grossman and Helpman [20] lobbies have more power in that they can directly influence the level of the trade policies. The earliest work that recognizes the influence of lobbyists on trade policy is provided by Hillman [23]. Our welfare function is most closely related to Baldwin [3] who uses a reduced form of the social welfare function in Hillman [23].

to political welfare, we also consider **social welfare**, which attaches the same unit weight to all aspects of welfare. Since tariffs are chosen to maximize political welfare the state of political pressure may still have an indirect effect on social welfare and we write it as $\Omega^U(\theta_{kt}) = V(\tau_{at}(\theta_{kt}), \tau^*_{at}(\theta_{kt}), \tau_{bt}(\theta_{kt}), \tau^*_{bt}(\theta_{kt})) + V^*(\tau_{at}(\theta_{kt}), \tau^*_{at}(\theta_{kt}), \tau_{bt}(\theta_{kt}), \tau^*_{bt}(\theta_{kt}))$ and the expectation as $E\Omega^U(\theta)$.[15]

The two most important elements of our model are given by the parameters D and θ. As we show below, if $D > 0$, then the tariffs are strategic substitutes as in the classic analyses of Johnson (1953-54) and Mayer (1981). On the other hand if $D = 0$, then the tariffs would be strategically independent. These results are illustrated in Figure 1 below and are derived formally in Lemma 1. For completeness, in Figure 1 we also include the case where $D < 0$.

Figure 1: Best response functions



Lemma 1. *If the utility functions are as given in equation (1) and the cost functions are as given in equation (2), then the following results hold.*

(i) The per-period political welfare in each sector is strictly concave in the domestic tariff and, for a domestic tariff in the neighborhood of zero, it is strictly increasing in the domestic tariff. It is strictly convex and monotonically decreasing in the foreign tariff,

(ii) The within-sector best-response tariffs are strategic substitutes.

(iii) For all $\theta \in [1, \bar{\theta})$, there is a unique Nash equilibrium in tariffs.

(iv) For all $\lambda \in [0, 1]$, there is a unique Bayes-Nash equilibrium in tariffs.

[15] If tariffs were chosen to maximize social welfare, then they would always be zero, and there would be no role for escape valves, safeguards, or on-schedule retaliation. In this case, same- and cross-sector retaliation would be the same.

All the proof are relegated to the Appendix. We denote Home, and Foreign, Nash equilibrium tariffs in sector i and state k as τ_{ik}^{N}, and τ_{ik}^{*N}, respectively. The non-cooperative political-welfare can then be written as $V^{N}(\theta_k) = V(\tau_{ak}^{N}(\theta_k), \tau_{ak}^{*N}(\theta_k), \theta_k, \tau_b^{N}, \tau_b^{*N})$ and $V^{*N}(\theta_k) = V^{*}(\tau_{ak}^{N}(\theta_k), \tau_{ak}^{*N}(\theta_k), \tau_b^{N}, \tau_b^{*N})$. Note that the non-cooperative tariffs in sector b do not depend on the state. Similarly, the Bayes-Nash equilibrium tariffs and corresponding political welfare can be written as $(\tau_{a\kappa}^{BN}, \tau_a^{*BN}, \tau_b^{N}, \tau_b^{*N})$, $V^{BN}(\theta_k) = V(\tau_{ak}^{BN}(\theta_k), \tau_a^{*BN}(E(\theta)), \theta_k, \tau_b^{N}, \tau_b^{*N})$ and $V^{*BN}(\theta) = V^{*}(\tau_{ak}^{BN}(\theta), \tau_a^{*BN}(E(\theta)), \tau_b^{N}, \tau_b^{*N})$. Note that Home's Bayes-Nash tariff depends on the current state as well as Foreign's expectation over that state and Foreign's is only a function of the expectation. Home's (and Foreign's) expectation, before the current state is revealed to them, of their political welfare in the Bayes-Nash equilibrium is $EV^{BN}(\theta)$ (and $EV^{*BN}(\theta)$). Information is complete in sector b and the Bayes-Nash equilibrium tariffs are exactly the same as the Nash-equilibrium tariffs described in part (iii), therefore, we use the same superscript as there. Still, because of sector a, we refer to the Bayes-Nash equilibrium for all sectors.

Tariffs are strategic substitutes for the following reason. The sector-specific sub-utility function shown in equation 1 exhibits a love of variety. Home's high-state import tariff generates a home bias in each country. An increase in Foreign's tariff exacerbates this home bias and further reduces the variety of consumption. To restore balance Foreign would prefer to reduce their tariff in response to an increase in Home's tariff.[16]

3.B Timing

The timing of the interaction is as follows. Each period consists of five stages. In the first stage, Home transfers a predetermined quantity, ζ, of the numeraire good to Foreign.[17] In the second stage, nature chooses a level of political pressure (θ). In the third stage, after observing nature's choice, Home makes an announcement ($\tilde{\tau}$) on its intended tariff. This announcement will reveal the state of its political pressure because any announced tariff that is larger than the low state tariff will reveal the state to be high.[18] In the

[16] In a traditional two-good general equilibrium framework (see, for example Johnson [21], Mayer [30], or Dixit [16]) an increase in the foreign import tariff lowers home income and, therefore, reduces home import demand. The home country then has less benefit from raising its own import tariff. For this reason, tariffs are strategic substitutes in a traditional framework. Our analysis requires at least four goods and two sectors and does not afford a closed form solution in a traditional general equilibrium framework (i.e. without a numeraire good to absorb all income effects).

[17] Since only Home has fluctuating political pressure their side payment (to be derived below) allows us to look for tariff solutions that yield symmetric outcomes on the payoff frontier. Alternatively, if Foreign were to have similar variations in political pressure with the same high-state level and probability, then (since, in each period, Home and Foreign would each levy the same high-state tariff and levy it with the same probability) the same outcome would obtain without a side payment. The side payment can be thought of as military, infrastructure, or medical assistance, or alternatively the permitted establishment of a military base. It may also be considered as concessions in additional international agreements that are not part of the covered agreements considered here. In many cases it would be the per-period amortized value of these items or concessions. In all cases the side payment is agreed upon at the signing of the agreement and before the current state is revealed. We assume that state-dependent transfers or side payments are not available and would not be allowed by the agreement. See Limão and Saggi [25] for more on state-dependent side payments and their limitations.

[18] Although it may seem more natural to have Home announce their state, we assume they announce their intended tariff for the following reason. The mechanism sets a maximum tariff for each state, but Home is naturally allowed to choose a lower

fourth stage, Foreign observes Home's announcement (but not nature's move) and the Home and Foreign tariffs are chosen simultaneously. In the fifth stage, production and consumption take place and markets clear.

In period t Foreign's actions are its tariffs, $\tau_t^* \equiv (\tau_{at}^*, \tau_{bt}^*)$ and Home's actions are its tariffs, $\tau_t \equiv (\tau_{at}, \tau_{bt})$, its announcement, $\tilde{\tau}_t$, and a decision, $\iota_t = \{0, 1\}$, whether or not to give the side payment. The public history at the beginning of period t is the sequence of payments, announcements, and tariffs through $t-1$, denoted as $I^{t-1} \times \tilde{T}^{t-1} \times T^{t-1} \times T^{*t-1}$, where $I^{t-1} = \iota_0, \iota_1, ..., \iota_{t-1}$, $\tilde{T}^{t-1} = \tilde{\tau}_0, \tilde{\tau}_1, ..., \tilde{\tau}_{t-1}$, $T^{t-1} = \tau_{0,}\tau_1, ..., \tau_{t-1}$, and $T^{*t-1} = \tau_{0,}^*\tau_1^*, ..., \tau_{t-1}^*$. In the perfect information benchmark the public history also includes the complete history of realizations of the political economy parameter: $\Theta^{t-1} = \theta_1, ..., \theta_{t-1}$, but under asymmetric information the realizations of this parameter are the private information of Home. A strategy for each country, in the asymmetric information version of model, is then $\sigma = (\sigma_t)_{t=0}^{\infty}$ and $\sigma^* = (\sigma_t^*)_{t=0}^{\infty}$ with $\sigma_t : I^{t-1} \times \Theta^{t-1} \times \tilde{T}^{t-1} \times T^{t-1} \times T^{*t-1} \times \theta_t \to \Re^3 \times \{0, 1\}$ and $\sigma_t^* : I^{t-1} \times \iota_t \times \tilde{T}^{t-1} \times T^{*t-1} \times T^{t-1} \times \tilde{\tau}_t \to \Re^2$. A strategy for each country maps the public history and any private information into the current period actions. For Home these actions include tariffs in each sector, their announcement, and their side-payment decision. Although, as written, strategies are history dependent, in the next several sections we ignore the history of past outcomes and assume that countries will abide by outlines of the trade agreement. Hence, actions are conditioned only on the current period state and we only consider tariff changes that are allowed by the trade agreement. After deriving what the trade agreement can accomplish when there is incomplete information about the current state we will consider the ability of history-dependent strategies to enforce adherence to the trade agreement. In particular, if Home does not apply the tariff that they announce, if their announcement is outside the allowable range, or if Home does not make the transfer payment, then they would abrogate the agreement. Similarly, Foreign would abrogate by choosing a tariff that is not allowable for Home's announcement. Since the per-period optimal on-agreement actions are independent of past realizations of the state variable we, therefore, omit the time subscript, t, to unclutter notation until we consider history dependent strategies in section 6 .

tariff. Any allowable Foreign retaliation is tied directly to Home's chosen tariff, therefore, Home's tariff choice (and not just their state) must be revealed before Foreign's choice. Although we allow Home to choose any tariff up to the maximum tariff for that revealed state, as will be seen below, they will always choose the maximum tariff for each state. If, instead, we allowed Home to choose their tariff in the third stage (as opposed to announcing their intention), then they would have a first-mover advantage over Foreign in tariff setting. This advantage would not matter as long as countries abide by the trade agreement, however, it would change the non-cooperative threat point if either country were to abrogate the agreement.

3.C Perfect-Information Benchmark

In this section we analyze the politically optimal tariffs when there is perfect information about Home's type. In particular, we look for tariffs that solve the following Nash-bargaining problem:

$$\max_{\tau_{aH},\tau_{aH}^*,\tau_{aL},\tau_{aL}^*,\tau_b,\tau_b^*}[EV(\tau_a,\tau_a^*,\theta,\tau_b,\tau_b^*)-EV^N(\theta)-\zeta_e]\times[EV^*(\tau_a,\tau_a^*,\tau_b,\tau_b^*)-EV^{*N}(\theta)+\zeta_e]$$

The side payment, ζ_e, is chosen to equalize the welfare gains from applying the on-schedule tariffs instead of the non-cooperative tariffs: $\zeta_e=[EV(\tau_a,\tau_a^*,\theta,\tau_b,\tau_b^*)-EV^N(\theta)-EV^*(\tau_a,\tau_a^*,\tau_b,\tau_b^*)+EV^{*N}(\theta)]/2$.

As we show in the proof to proposition 1 below, the solution to the above maximization problem is the same as if the tariffs are chosen to maximize Home's and Foreign's expected joint-welfare function: $E\Omega(\theta)$. We use two observations to simplify this optimization problem. First, because each country's welfare is separable in the sectors, we solve each sector's optimization problem separately. Second, given that the state is revealed before tariffs are chosen, we divide the sector a welfare maximization problem into a low-state, θ_L, and a high-state, θ_H, case. The perfect-information optimization problem can then be written as:

$$\begin{aligned}&\max_{\tau_{aL},\tau_{aL}^*}\Omega_a(\tau_{aL},\tau_{aL}^*,\theta_L)=\max_{\tau_{aL},\tau_{aL}^*}\vartheta_a(\tau_{aL},\tau_{aL}^*,\theta_L)+\vartheta_a^*(\tau_{aL},\tau_{aL}^*);\\&\max_{\tau_{aH},\tau_{aH}^*}\Omega_a(\tau_{aH},\tau_{aH}^*,\theta_H)=\max_{\tau_{aH},\tau_{aH}^*}\vartheta_a(\tau_{aH},\tau_{aH}^*,\theta_H)+\vartheta_a^*(\tau_{aH},\tau_{aH}^*);\end{aligned}\tag{8}$$

and

$$\max_{\tau_b,\tau_b^*}\Omega_b(\tau_b,\tau_b^*)=\max_{\tau_b,\tau_b^*}\vartheta_b(\tau_b,\tau_b^*)+\vartheta_b^*(\tau_b,\tau_b^*).\tag{9}$$

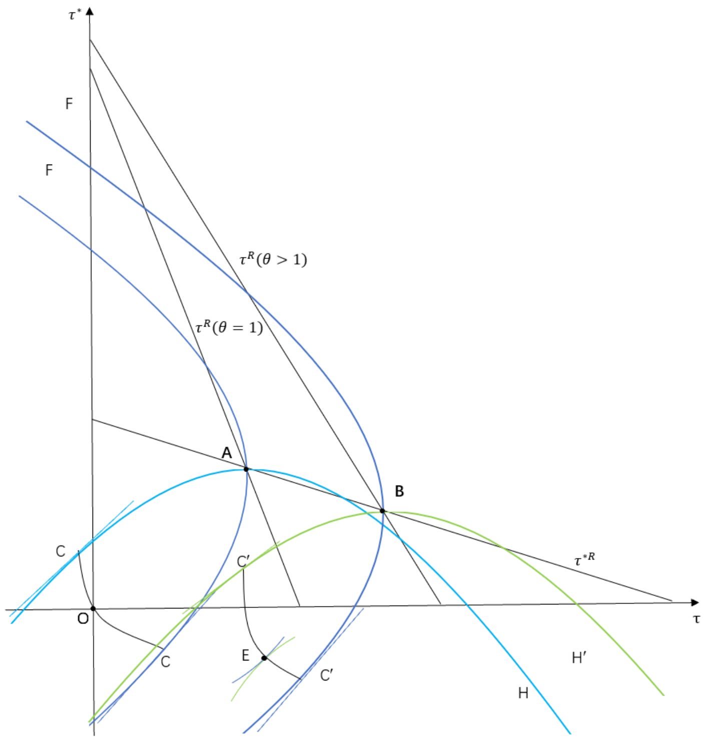
Using superscript letter "e " to represent "politically efficient" and solving the above maximization problems yields the following proposition:

Proposition 1. *The joint political-welfare-maximizing tariffs under perfect information are*

$$\begin{gathered}\tau_{aL}^e=\tau_{aL}^{*e}=\tau_b^e=\tau_b^{*e}=0;\\ \tau_{aH}^{*e}=-\frac{D}{2}\frac{(\theta_H-1)(2Df-3f+2A)}{(D-2)(D^2+\theta_H-5)}<0<\tau_{aH}^e=\frac{(\theta_H-1)(2Df+2A-3f)}{(D-2)(D^2+\theta_H-5)}.\end{gathered}$$

The essence of Proposition 1 is shown in Figure 2 where we illustrate the two possible states for sector a. The non-cooperative outcome for the low state is given by point A in Figure 2 where there is a unique intersection of each country's tariff best-response function. We also illustrate the iso-welfare for each country that passes through point A. From these iso-welfare curves we can draw the contract curve in tariff space as curve CC. Note that this contract curve passes through the origin. Both countries prefer any outcome on CC to that at point A. The joint welfare optimization chooses point O, where $\tau_{aL}^e=\tau_{aL}^{*e}=0$ is the unique solution for sector a in the low state (and also for sector b).

Figure 2: Perfect Information Benchmark



In the high state, Home's best-response is more responsive to a foreign tariff. The non-cooperative outcome for the high state is given by point B. The iso-welfare for Foreign passing through point B has the same shape as that through point A, but the iso-welfare curve for Home (labeled H') reflects the fact that in a high state Home would like a larger protective tariff for its import-competing industry and will tolerate a larger foreign tariff in retaliation. From these two iso-welfare curves passing through point B we can construct the high state contract curve C'C' and the joint optimum is given on that curve at point E. At point E the optimum Home tariff is positive and the Foreign tariff is negative. That is, at the high-state perfect-information optimum Foreign should subsidize imports to reduce Home's import tariff. This interesting result occurs because the tariffs are strategic substitutes (and because $\theta_H > 1$). On the other hand, if $D = 0$, then Foreign's tariff would be zero regardless of Home's state. Note as well from proposition 1 that Home's tariff is increasing in θ and is zero if and only if $\theta = 1$, therefore, the politically efficient high-state tariffs do not maximize social welfare.

We now consider the more interesting case whereby Foreign does not know the realization of θ.

4 Incomplete Information with Deterministic Retaliation

From this point on we assume that foreign does not know Home's type, but it perfectly observes Home's action. Hence, if Home adheres to the tariff schedule given by the trade agreement, then Foreign can infer its type in any period. Home must be induced to announce its type truthfully, otherwise Home would always announce a high state. We begin with a simple revelation mechanism suggested by the GATT, and by the WTO DSU, which allows Foreign to choose any tariff up to the full reciprocating tariff that would leave the initial volume of trade unchanged.

Since θ takes two values we consider a Home tariff schedule that also takes on two values that prescribe maximum allowable tariffs for each state. For same-sector retaliation considered in the next subsection these values are $\tau_{aL}(\theta_L)$ and $\tau_{aH}(\theta_H)$. A tariff greater than $\tau_{aL}(\theta_L)$ but no more than $\tau_{aH}(\theta_H)$ is interpreted as a high state tariff and Foreign can respond reciprocally. A tariff greater than $\tau_{aH}(\theta_H)$ is considered as an abrogation of the trade agreement and is analyzed in section 6. Although Home could choose a lower tariff than the maximum allowable tariff they will always choose the given optimal tariffs for each state: $\tau_{aL}(\theta_L)$ and $\tau_{aH}(\theta_H)$. To see this point note that, as we show below, the optimal tariffs maximize joint welfare for a particular Home state given the reciprocity condition. In the low state the countries are symmetric, therefore, the maximization of joint welfare (given reciprocity) yields the same result as the maximization of Home welfare: zero tariffs. In the high state Home would prefer a larger tariff and Foreign would still prefer a zero tariff. The joint welfare maximization tariff is between these values and less than Home's preferred tariff, therefore, they will always choose to apply the maximum allowable tariff for a given state. This same intuition is also applicable to cross-sector retaliation considered below and to probabilistic retaliation as considered in section 5.

In this section we abstract from several important issues which we address below. First, we start by considering only same-sector, and then only cross-sector retaliation before we allow Foreign to choose their preferred sector or agreement for retaliation. Second, we initially ignore the incentive compatible constraint. We then show that this constraint is slack under full deterministic reciprocity. We, therefore, analyze probabilistic or delayed retaliation in section 5, and we see there that it permits the incentive compatible constraint to bind which allows the mechanism to generate greater welfare. Since the voluntary participation constraints for this framework are given by the incentive constraints for the infinitely repeated game we delay their analysis until section 6. Finally, to capture the idea that trade policy is determined by export as well as import-competing interests we introduce political pressure and welfare weights on the export goods in either or in both sectors in section 7.

4.A Same-sector Retaliation

Following Bagwell and Staiger [5], we define same-sector full reciprocity as a set of high-state tariffs such that

$$p^*_{x_a}(\tau^*_{aL})[M^*_{x_a}(\tau_{aH},\tau^{*FRS}_{aH}) - M^*_{x_a}(\tau_{aL},\tau^*_{aL})] = p_{y_a}(\tau_{aL})[M_{y_a}(\tau_{aH},\tau^{*FRS}_{aH}) - M_{y_a}(\tau_{aL},\tau^*_{aL})] \tag{10}$$

where the change in the volume of trade is evaluated at the original prices and the full expression for imports are as given in equation (6). Given the symmetry between the countries (other than Home's high-state political pressure) and from equations (6) and (10) we have that if $\tau_{aL}(\theta_L) = \tau^*_{aL}(\theta_L)$, then full reciprocity can be expressed as $\tau^{*FRS}_{aH} = \tau_{aH}(\theta_H)$. Full reciprocity implies an upper bound on Foreign's high-state tariff, however, they are free to choose any lower tariff. Foreign's unconstrained best-response is given by $\tau^{*R}_{aH} = \frac{f - D\tau_{aH}}{6}$ and when constrained by the full reciprocity condition Foreign's reciprocal response is then $\tau^{*RRS}_{aH} = min\{\tau^{*FRS}_{aH}, \frac{f-D\tau_{aH}}{6}\}$. As shown below $\tau^{*FRS}_{aH} < \frac{f-D\tau_{aH}}{6}$ so that, in equilibrium, Foreign will always use full reciprocity and set $\tau^{*RRS}_{aH} = \tau^{*FRS}_{aH}$, however, by separately notating $\tau^{*RRS}_{aH}, \tau^{*FRS}_{aH}$, and τ^{*R}_{aH} we make it explicit that Foreign will want to use the full amount of their permitted retaliatory tariff.

We again look for tariffs that solve a Nash bargaining problem where the countries have equal bargaining power. The tariffs for each state and the side payment are chosen before the realization of the state, therefore, the maximization problem can be written as

$$\max_{\tau_{aH},\tau^*_{aH},\tau_{aL},\tau^*_{aL},\tau_b,\tau^*_b} [EV(\tau_a,\tau^*_a,\theta,\tau_b,\tau^*_b) - EV^{BN}(\theta) - \zeta_S] \times [EV^*(\tau_a,\tau^*_a,\tau_b,\tau^*_b) - EV^{*BN}(\theta) + \zeta_S] \tag{11}$$

subject to

$$\tau^*_{aH} = \tau^{*RRS}_{aH} = min\{\tau^{*FRS}_{aH}, \frac{f - D\tau_{aH}}{6}\}, \tag{12}$$

$$\tau_{aL} \geq 0, \tau^*_{aL} \geq 0, \tau_{aH} \geq 0, \tau^*_{aH} \geq 0, \tau_b \geq 0, \tau^*_b \geq 0, \tag{13}$$

$$\vartheta_a(\tau_{aL},\tau^*_{aL},\theta_L) \geq \vartheta_a(\tau_{aH},\tau^*_{aH},\theta_L), \tag{14}$$

$$\vartheta_a(\tau_{aH},\tau^*_{aH},\theta_H) \geq \vartheta_a(\tau_{aL},\tau^*_{aL},\theta_H). \tag{15}$$

The side payment, ζ_S, is chosen to equalize the welfare gains from applying the trade-agreement tariffs instead of the non-cooperative tariffs: $\zeta_S = \frac{EV(\tau_a,\tau^*_a,\theta,\tau_b,\tau^*_b) - EV^{BN}(\theta) - EV^*(\tau_a,\tau^*_a,\tau_b,\tau^*_b) + EV^{*BN}(\theta)}{2}$.

The reciprocity constraint is written in equation (12). The tariff non-negativity constraint is given by equation (13). To ensure truthful revelation of θ, the tariff scheme needs to be incentive compatible for Home. Equation (14) is the incentive compatibility condition for the low state and equation (15) is that for the high state. The voluntary participation constraints for this type of framework are given by the incentive constraints for the infinitely repeated game. We analyze these constraints in section 6.[19]

We show in the appendix that the solution to the above problem is the same as the solution to the maximization of expected joint political welfare. Furthermore, notice that for same-sector retaliation we can, as in proposition 1, analyze the maximization problem in each sector separately.

The negotiators' maximization problem in sector b is the same as in the perfect-information benchmark, and it has the same solution, $\tau_b^S = \tau_b^{*S} = 0$ as in proposition 1. The negotiators' maximization problem in sector a is given by:

$$\max_{\tau_{aL}, \tau_{aH}, \tau^*_{aL}, \tau^*_{aH}} (1-\lambda)\Omega_a(\tau_{aL}, \tau^*_{aL}, \theta_L) + \lambda\Omega_a(\tau_{aH}, \tau^*_{aH}, \theta_H) \tag{16}$$

subject to constraints (12) – (15).

We, at first, ignore the incentive-compatible constraints and then we show that these constraints are satisfied at the unconstrained solution. We use the term **incentive-unconstrained** to denote the solution to a maximization problem subject only to the reciprocity and non-negativity constraints and we write these incentive-unconstrained solutions as $(\tau^S_{aL}, \tau^S_{aH}, \tau^{*S}_{aL}, \tau^{*S}_{aH})$, where the superscript "S" represents "same-sector". We then have the following proposition.

Proposition 2. *Under a same-sector retaliation mechanism,*

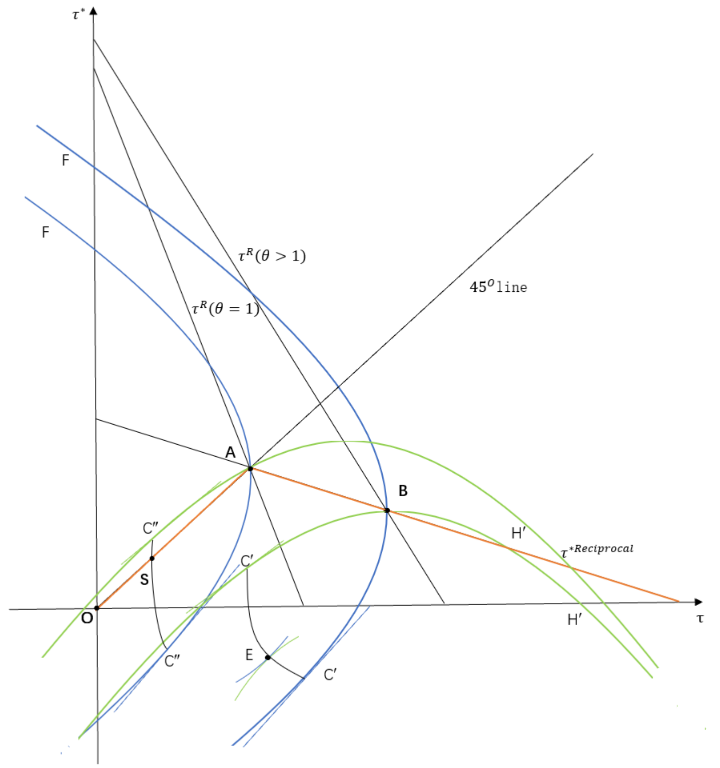
(i) the incentive-unconstrained joint political-welfare-maximizing import tariffs are

$$\tau_b^S = \tau_b^{*S} = \tau^S_{aL} = \tau^{*S}_{aL} = 0 < \tau^S_{aH} = \tau^{*S}_{aH} = \frac{(\theta_H - 1)(2A + 2Df - 3f)}{(D-2)(\theta_H - 4D - 9)},$$

(ii) the incentive-unconstrained joint political-welfare-maximizing import tariff in a high state is smaller than the politically efficient tariff: $\tau^S_{aH} < \tau^e_{aH}$.

[19] The use of a Nash-bargaining game whose solution is dynamically enforced by repeated interaction is not unique to our framework. It was first introduced to analyze firm collusion by Harrington [22] and to analyze trade agreements by Bac and Raff [2], Furusawa [18], and Maggi [27].

Figure 3: Same-sector Retaliation

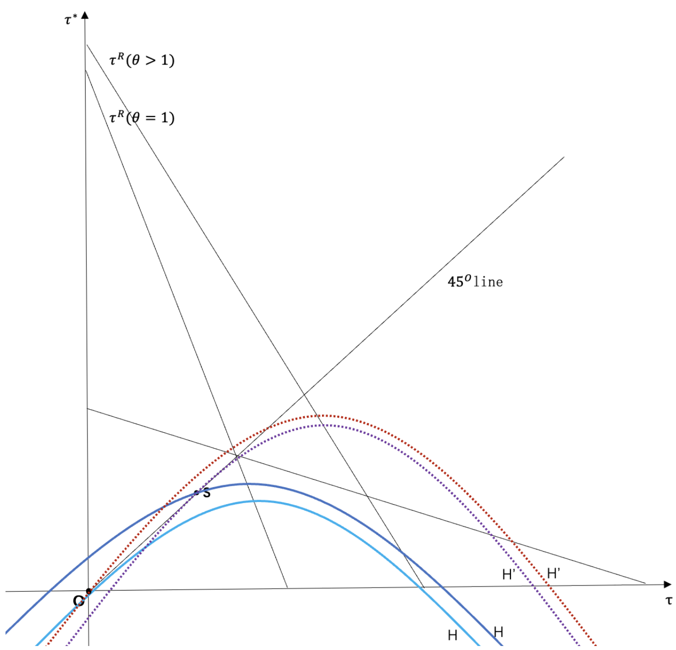


The essence of Proposition 2 is illustrated in Figure 3 (and the proof is in the appendix). As in Figure 2, the non-cooperative Nash tariffs are given by point B. Foreign's reciprocal response is $\tau_{aH}^{*RRS} = min\{\tau_{aH}^{S}, \frac{f-D\tau_{aH}^{S}}{6}\}$ which follows the forty-five degree line passing through the origin until $\tau_{aH}^{S} = \frac{f}{6+D}$, which is given as point A. As we show in the appendix, the condition $\theta < \bar{\theta}$ ensures that $\tau_{aH}^{S} < \frac{f}{6+D}$, therefore, Foreign will match Home's high-state tariff. The largest possible fully reciprocal tariff is then given by point A. Drawing iso-welfare curves through point A, we can then construct the contract curve, which is depicted as curve C"C". The reciprocity condition allows equivalent tariffs (on the forty-five degree line) and the solution is given by point S. As shown formally in proposition 2 this tariff is increasing in θ_H and larger than that in the low state (unless $\theta_H = 1$), but it is less than the politically-efficient high-state Home tariff. To ensure truthful revelation of the state the reciprocity condition generates a cost to any tariff increase, therefore, Home will raise their tariff to less than the politically efficient level. It is straightforward to see that the incentive-unconstrained optimum also satisfies the non-negative tariff constraint.

The next proposition shows that the incentive compatibility constraints are slack under the same-sector retaliation mechanism. Therefore, the incentive-unconstrained solutions also satisfy the constrained maximization problem.

Proposition 3. *Under a same-sector retaliation mechanism with incentive-unconstrained solutions the incentive compatibility conditions (14) and (15) are slack.*

Figure 4: Same-sector Incentive Compatibility



The idea of Proposition 3 is illustrated in Figure 4. In the low state both countries prefer free trade to any positive reciprocated tariff, therefore, Home is on a higher iso-welfare curve if it does not misrepresent its type in the low state. In the high state Home's iso-welfare curves are denoted as H' and it is seen that Home has greater welfare at point S than at any other set of reciprocal tariffs. Hence, Home would not want to incorrectly claim that it is a low state (nor would they want to choose any tariff less than the maximum allowable high-state tariff). Given that neither of the incentive-compatibility constraints are binding, it indicates that these equivalent retaliation strategies are too strict. In section 5 we, therefore, consider a less severe punishment mechanism. Before turning to a more efficient truth-telling mechanism, we first analyze cross retaliation.

4.B Cross-sector Retaliation

In this section, we consider cross-retaliation, or linked agreements. The on-schedule requirements in this cross-sector retaliation mechanism are as follows. When Home announces a low-state tariff both countries set low-state tariffs in both sectors: $\tau_{aL}(\theta_L)$, $\tau_{bL}(\theta_L)$, $\tau^*_{aL}(\theta_L)$, $\tau^*_{bL}(\theta_L)$. If Home announces a high-state tariff, then Home can set the high-state tariff in sector a, $\tau_{aH}(\theta_H)$, and they maintain the low-state tariff in sector b, $\tau_{bH} = \tau_{bL}(\theta_L)$. Foreign, on the other hand, still levies the low-state tariff in sector a, $\tau^*_{aH} = \tau^*_{aL}(\theta_L)$, but can impose a retaliatory tariff, τ^{*RRC}_{bH}, subject to the reciprocity constraint in sector b.[20] Rewriting equation (10) for cross-sector retaliation implies a full reciprocity tariff, τ^{*FRC}_{bH}, that satisfies $p^*_{x_b}(\tau^*_{bL})[M^*_{x_b}(\tau_{bH}, \tau^{*FRC}_{bH}) - M^*_{x_b}(\tau_{aL}, \tau^*_{aL})] = p_{y_a}(\tau_{aL})[M_{y_a}(\tau_{aH}, \tau^*_{aH}) - M_{y_a}(\tau_{aL}, \tau^*_{aL})]$. Foreign's unconstrained response is given by $\tau^{*R}_{bH} = \frac{f - D\tau_{bH}}{6}$, therefore, Foreign's reciprocal response is $\tau^{*RRC}_{bH} = min\{\tau^{*FRC}_{bH}, \frac{f-D\tau_{bH}}{6}\}$. The negotiators choose tariffs to

$$\max_{\tau_{aH},\tau^*_{aH},\tau_{aL},\tau^*_{aL},\tau_{bL},\tau^*_{bL},\tau_{bH},\tau^*_{bH}} [EV(\tau_a, \tau^*_a, \theta, \tau_b, \tau^*_b) - EV^{BN}(\theta) - \zeta_C] \times EV^*(\tau_a, \tau^*_a, \tau_b, \tau^*_b) - EV^{*BN}(\theta) + \zeta_C] \tag{17}$$

subject to

$$\tau^*_{bH} = \tau^{*RRC}_{bH} = min\{\tau^{*FRC}_{bH}, \frac{f - D\tau_{bH}}{6}\}, \tag{18}$$

$$\tau^*_{aH} = \tau^*_{aL}, \tau_{bH} = \tau_{bL}, \tag{19}$$

$$\tau_{aL} \geq 0, \tau^*_{aL} \geq 0, \tau_{aH} \geq 0, \tau^*_{aH} \geq 0, \tau_{bL} \geq 0, \tau^*_{bL} \geq 0, \tau_{bH} \geq 0, \tau^*_{bH} \geq 0, \tag{20}$$

$$\vartheta_a(\tau_{aL}, \tau^*_{aL}, \theta_L) + \vartheta_b(\tau_{bL}, \tau^*_{bL}) \geq \vartheta_a(\tau_{aH}, \tau^*_{aH}, \theta_L) + \vartheta_b(\tau_{bH}, \tau^*_{bH}), \tag{21}$$

$$\vartheta_a(\tau_{aH}, \tau^*_{aH}, \theta_H) + \vartheta_b(\tau_{bH}, \tau^*_{bH}) \geq \vartheta_a(\tau_{aL}, \tau^*_{aL}, \theta_H) + \vartheta_b(\tau_{bL}, \tau^*_{bL}). \tag{22}$$

The side payment, ζ_C, is chosen to equalize the welfare gains from applying the on-schedule tariffs instead of the non-cooperative tariffs: $\zeta_C = \frac{EV(\tau_a,\tau^*_a,\theta,\tau_b,\tau^*_b) - EV^{BN}(\theta) - EV^*(\tau_a,\tau^*_a,\tau_b,\tau^*_b) + EV^{*BN}(\theta)}{2}$.

The constraints are similar to those in the same sector case. The only additional constraint is given by equation (19) which stipulates that if Home announces a High state, then Home (Foreign) must maintain its low-state tariff in sector b (a). By solving the incentive-unconstrained maximization problem (where we temporarily ignore the incentive-compatible conditions, (21) and (22)), we have the following proposition.

Proposition 4. *(i) The incentive-unconstrained joint political-welfare-maximizing tariffs under a cross-sector retaliation mechanism are as follows:*

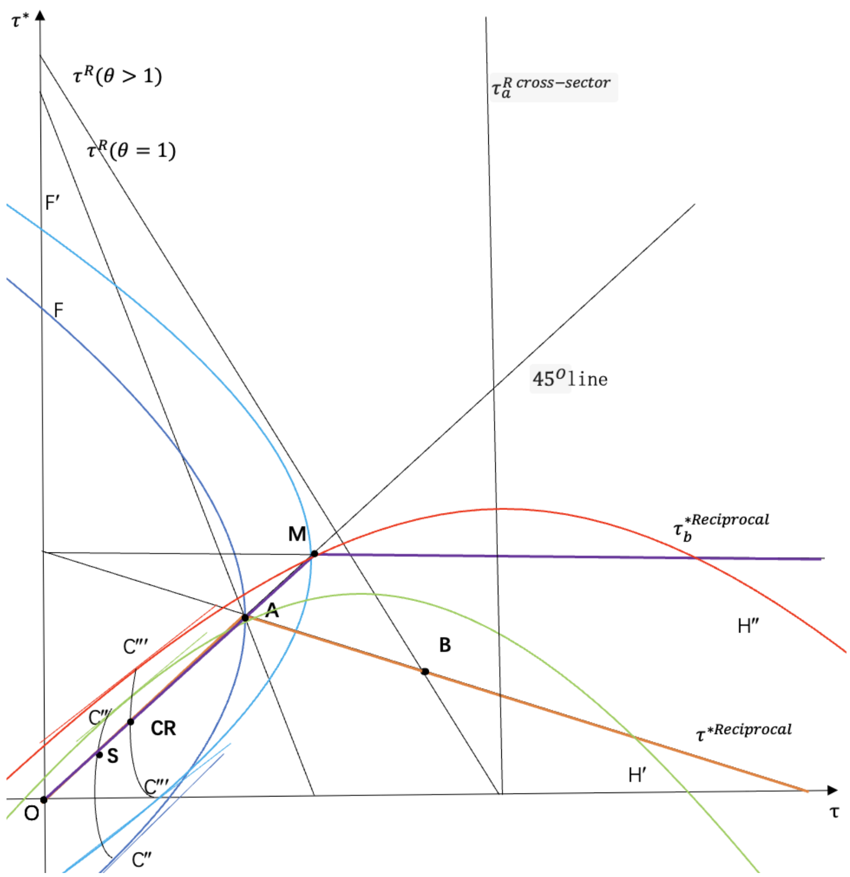
$$\tau^C_{bL} = \tau^{*C}_{bL} = \tau^C_{aL} = \tau^{*C}_{aL} = \tau^C_{bH} = \tau^{*C}_{aH} = 0 < \tau^C_{aH} = \tau^{*C}_{bH} = \frac{(\theta_H - 1)(2A + 2Df - 3f)}{(D-2)(\theta_H - 9)}.$$

(ii) The incentive-unconstrained joint political-welfare-maximizing tariff in a high state under a cross-sector

[20] Although the politically-efficient high-state tariff for Foreign in sector a is negative (as shown in proposition 1) the non-negativity constraint implies a continuation of the low-state efficient tariff, which is zero. Although it would mildly complicate the analysis to incorporate on-schedule import subsidies it would have no qualitative effect on the results. Since import subsidies are not observed in international commerce and are not discussed in trade negotiations we proceed with the more realistic (if slightly less efficient) cross-sector mechanism whereby Foreign is only required to set a non-negative tariff in sector a when Home chooses a high tariff.

retaliation mechanism is greater than under a same-sector retaliation mechanism while smaller than the politically efficient tariff: $\tau^S_{aH} < \tau^C_{aH} < \tau^e_{aH}$.

Figure 5: Cross-sector Retaliation

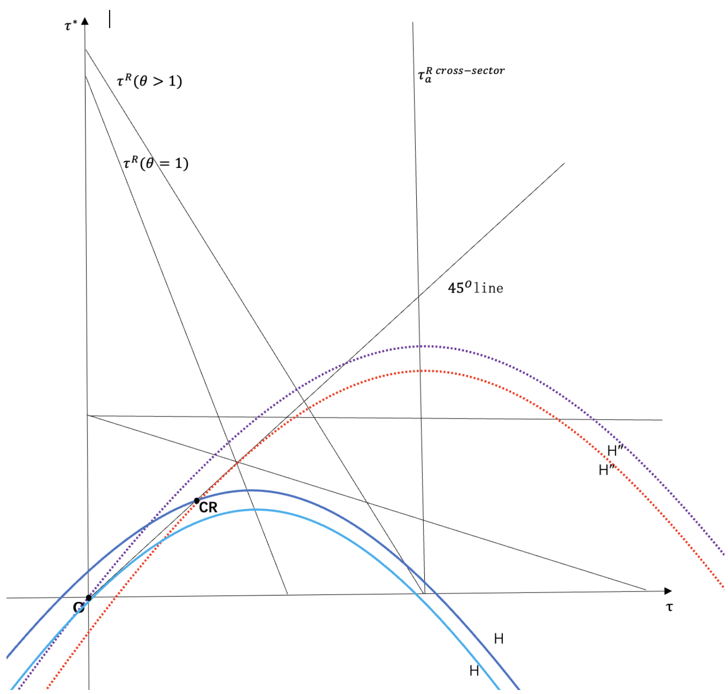


The idea of Proposition 4 is illustrated in Figure 5 (the full proof is in the appendix), where we try to capture cross-retaliation across two sectors in a single two-dimensional figure. If Home chooses a high-state tariff in sector a it treats the foreign tariff as given, therefore, it no longer considers the tariffs in sector a as strategic substitutes. For this reason, Home's best response is shown by the vertical line labeled $\tau_a^{Rcross-sector}$ that crosses the horizontal axis at Home's high-state best response to a Foreign sector a zero tariff. Similarly Foreign's best response in sector b uses the fact that $\tau^C_{bH} = \tau^C_{bL} = 0$, and it is a horizontal line that crosses the vertical axis at Foreign's best response to a Home sector b zero tariff. Foreign's allowed reciprocal best response is given by $\tau^{*RRC}_{bH} = min\{\tau_{aH}, \frac{f}{6}\}$ which follows the forty-five degree line until $\tau^C_{aH} = \frac{f}{6}$ (as we show in the appendix, the condition $\theta < \bar{\theta}$ ensures that $\tau^C_{aH} < \frac{f}{6}$), which is given as point M in the figure. From the iso-welfare curves passing through point M we can construct the new contract curve C"'C"'. This contract curve passes through the forty-five degree line at point CR, yielding the high-state cross-sector retaliation tariffs and these tariffs are larger than those under same-sector retaliation as shown by point S.[21]

Similar to the same-sector retaliation case, the solution to the incentive-unconstrained cross-sector problem satisfies the incentive compatibility constraints, therefore, the optimal tariffs described in proposition 4 also solve the constrained problem.

Proposition 5. *Under a cross-sector retaliation mechanism with incentive-unconstrained solutions the incentive compatibility conditions (21) and (22) are slack.*

Figure 6: Cross-sector Incentive Compatibility



Proposition 5 is illustrated in figure 6, which is similar to figure 4. The proof of both cases is in the appendix.

[21] If we plug the high-state tariffs, τ_{aH}^C and τ_{aH}^S into the demand and supply functions we can then find an upper bound on θ_H so that imports are positive if and only if θ_H is less than this upper bound. For same-sector retaliation, this upper bound is $\theta_H < \frac{4A+2AD+f(12+2D^2)}{4A+2AD-f(4-2D^2)}$ and for cross-sector retaliation it is $\theta_H < \frac{4A+f(12-5D)}{4A+f(3D-4)}$. Because $D < 1$ and $A > 2f$ both of these expressions are greater than one and comparison shows that the cross-sector upper bound is lower. Similarly, as shown in the appendix, we can find upper bounds on θ such that Foreign will use the full allowable reciprocal retaliation. For same-sector retaliation, this upper bound is $\theta_H < \frac{6A+AD+4Df-D^2f}{6A+AD-8f+4Df+D^2f}$ and for cross-sector retaliation it is $\theta_H < \frac{12A+3Df}{12A+(-16+11D)f}$. Both of these expressions are also greater than one and again the cross-sector upper bound is lower. All of these expressions are decreasing in D and A and attain their supremum when A approaches $2f$ and D approaches 0.

4.C Comparing Cross- and Same-Sector Retaliation

In this section we compare cross-sector and same-sector retaliation. First we analyze political welfare, then we consider social welfare. Finally we also allow Foreign to choose its sector of retaliation.

From Propositions 3 and 5, we know that the optimal incentive-compatible tariffs are the same as the incentive-unconstrained tariffs given in Propositions 2 and 4. We use these tariffs to compare the political welfare implications of the two mechanisms in the following proposition, which is our first main result.

Proposition 6. *The joint political-welfare-maximizing incentive-compatible negotiated import tariffs under a cross-sector retaliation mechanism generate greater joint political welfare than do the joint political-welfare-maximizing incentive-compatible negotiated tariffs under a same-sector retaliation mechanism.*

There are two cases considered in the proof of proposition 6 (shown in the appendix). In a low state the two mechanisms deliver the same efficient tariffs. The more interesting case is the high state. Although high-state tariffs are larger with cross-sector retaliation, they generate greater welfare. There are two reasons for this result. First, if both mechanisms had the same tariffs, then because tariffs are strategic substitutes within a sector, they would lower welfare less if Foreign and Home levied theirs in different sectors. The intuition here is related to the home bias effect of tariffs noted above. When Home raises its import tariff it generates a home bias in both countries. Foreign's retaliatory tariff generates additional home bias, but given the love of variety structure of the utility function it is better to have balanced consumption in both sectors (i.e. a small amount of home bias in both sectors) than unbalanced consumption and a large amount of home bias in one sector. The second reason is because both sets of high-state mechanism tariffs are less than the efficient level, but the high-state cross-sector retaliation tariffs are closer to the efficient level: $\tau_{aH}^S < \tau_{aH}^C < \tau_{aH}^e$. This result occurs because the retaliatory tariff in either mechanism is tied to the chosen high-state tariff, which causes the high-state tariff to be less than the perfect information level. Hence, if retaliation is restricted to take place in the same sector, then the lower tariffs chosen in the same-sector mechanism reduce the mechanism's efficiency. These two effects work together to generate greater political welfare for the cross-sector mechanism.

Social welfare considers all states as the low state, therefore, the social-welfare maximizing tariffs are zero. Hence, for strategically independent tariffs social welfare is larger under the mechanism with lower tariffs. On the other hand, if tariffs were the same in both mechanisms, then they would lower social welfare less if Home and Foreign applied them in different sectors (since tariffs are strategic substitutes within a sector the intuition is the same as the home-bias effect discussed above). For social welfare, therefore, these two effects work in opposite directions. In the following proposition, we show that the larger tariff effect dominates the strategic substitute effect so that social welfare is larger under same-sector as opposed to cross-sector retaliation. The second part of the proposition shows that if tariffs are the same under both mechanisms, then social welfare would be larger with cross retaliation.

Proposition 7. *(i) The joint political-welfare-maximizing incentive-compatible import tariffs under a cross-sector retaliation mechanism generate less joint social welfare than do those under a same-sector retaliation mechanism.*

(ii) If tariffs are the same under both mechanisms, then joint social welfare is greater under a cross-sector retaliation mechanism than under a same-sector retaliation mechanism.

Part (ii) of Proposition 7 is relevant if Foreign can choose the sector, or agreement, of retaliation after the high-state tariff is chosen. In this case, the tariff is already fixed, therefore, the lower-tariff effect of same-sector retaliation is lost and only the direct strategic substitute effect remains. Hence, social welfare would be greater if Foreign retaliates cross sector.

The next proposition takes this idea further and asks, if given the choice, then which sector would Foreign choose for retaliation. It then analyzes if they would want that freedom to choose. The important distinction between this result and part (ii) of the previous Proposition is that this case considers only Foreign's political welfare as opposed to the combined social welfare world of both countries. Since there are no political pressure fluctuations in Foreign it turns out that their political welfare is the same as their social welfare. The intuition here is again that once Home's tariffs are set Foreign's reciprocal response is limited by Home's chosen tariff. The relevant comparison for Foreign must, therefore, consider the same reciprocal tariff for either cross- or same-sector retaliation. Given that tariffs are strategic substitutes within a sector Foreign's welfare is greater if they retaliate cross sector. Hence, if given the choice of retaliatory sector after the high-state tariff and maximum retaliatory tariff are established, then Foreign prefers cross-sector retaliation ex-post. On the other hand, since Foreign's political welfare is the same as their social welfare, their political welfare is greater under the same-sector retaliation mechanism. Put another way, if they could choose Home's high state tariff, then they would prefer the lower same-sector tariff. Hence, Foreign would prefer if they did not have the choice and cross-sector retaliation was not allowed ex-ante.

Proposition 8. *(i) If allowed to choose the sector of retaliation after Home sets its high-state tariff, then Foreign will retaliate cross sector. (ii) Foreign political and social welfare are both greater under the same-sector retaliation mechanism.*

Proposition 8 shows that Foreign will choose cross-sector retaliation ex-post and Proposition 6 suggest that the WTO is maximizing its members' joint political welfare by giving them that choice. We can then state the following corollary of Propositions 6 and 8.

Corollary 1. *Joint political welfare is maximized by allowing Foreign to choose the sector of retaliation. For any given Home high-state tariff they will choose cross-sector retaliation and Home will, therefore, choose the high-state tariff given by the cross-sector mechanism.*

In our model Foreign would prefer if retaliation is limited to the same sector, but that is because they never have a high state, which is an assumption made for tractability. If the symmetry between the countries extended to equal probabilities of a high-state of political pressure, then ex-ante Foreign welfare would also be greater if cross-sector retaliation we allowed. Still, it is interesting to note that for any particular high state it would be the retaliating country that would prefer the restriction against cross-retaliation before the high-state tariff is chosen.

4.D Cross-sector versus cross-agreement retaliation

We now consider the difference between same agreement and cross-agreement retaliation. We, therefore, assume that there are at least two sectors in each agreement and that goods in these additional within-agreement sectors exhibit an extent of substitutability $D > 0$ with goods in the original Home high-tariff sector. In this way we can analyze the retaliation choice between related sectors in agreement a and unrelated sectors covered by agreement b.

From the proof of Proposition 8, we have that for a given high-state tariff, denoted as $\bar{\tau}_{aH}$, the difference between Foreign's political welfare from cross- and same-agreement retaliation is given as $V^*(\bar{\tau}_{aH}, 0, 0, \bar{\tau}_{aH}) - V^*(\bar{\tau}_{aH}, \bar{\tau}_{aH}, 0, 0) = \frac{D(\bar{\tau}_{aH})^2}{4}$. Foreign's welfare gain from cross-agreement retaliation is increasing in the parameter D and is, therefore, larger if the available sectors for retaliation in agreement a are closer substitutes to the original Home high-tariff sector. As shown in the following proposition, the joint political-welfare benefit from cross-agreement over same-agreement retaliation is also greater if the sector of retaliation in the same agreement is a closer substitute to the original high-state good or sector. We combine these two results in the following proposition.

Proposition 9. *If the goods or sectors available for retaliation in agreement* a *have extent of substitutability* D *with goods in the original Home high-tariff sector, then Foreign's preference for, and the joint political-welfare benefit from, cross-agreement retaliation is increasing in this extent of substitutability parameter* D.

Proposition 9 is an obvious extension of Propositions 6 and 8 to cross-agreement retaliation. The converse is the most interesting part of this proposition. The political-welfare gain from allowing cross-agreement retaliation is limited if there are available goods in the original agreement that are not closely related to the Home's high-tariff sector. Since cross-agreement retaliation requires calculating tariff equivalents for non-tariff barriers, if we were to include this additional cost of cross-agreement retaliation in our model, then this result suggests why the WTO is permissive with respect to cross-sector, but not cross-agreement, retaliation.

5 Probabilistic Retaliation

As shown in propositions 3 and 5, same-sector and cross-sector retaliation mechanisms are both too strong because they require excessive retaliation. We now consider more efficient asymmetric-retaliation mechanisms and we compare the welfare effects of cross-sector and same-sector retaliation in these asymmetric mechanisms. The inefficiency of a symmetric mechanism arises because in a high state the countries are not symmetric: Home has greater political pressure than Foreign. One possibility for an asymmetric mechanism would allow Foreign to counter an on-schedule deviation with a less than reciprocal tariff. On the other hand, as noted in the introduction, reciprocity is a founding principal of the WTO (and its predecessor the GATT). We, therefore, still permit up to an equal removal of concessions, but allow for retaliation to be less than certain. In particular, we model the uncertainty in the dispute mediation process as a parameter, γ, which corresponds to the probability that Foreign is permitted to reciprocally retaliate against Home's tariff increase. If $\gamma < 1$, then the expected rate of retaliation is less than reciprocal. Although we begin by treating this probability as an exogenous parameter we endogenize it for each mechanism below and compare the tariff and welfare implications of same- and cross-sector retaliation when this probability is chosen optimally for each regime. Since the results from this section do not change any of the results from the deterministic retaliation section all derivations and proofs are relegated to our online appendix (Chisik and Fang [14]).

5.A Same-sector Probabilistic Retaliation

When Home announces a high state and sets the high-state tariff, Foreign is allowed to retaliate, subject to the reciprocity constraint, with probability $\gamma \in [0, 1]$. With probability $1 - \gamma$ they cannot retaliate and must levy the negotiated low-state tariff. We write $V^S(\tau_a, \tau_a^*, \theta_k, \tau_b, \tau_b^*, \gamma)$ to indicate Home's same-sector probabilistic mechanism expected political welfare after the state is revealed so that, when the state is high, $V^S(\tau_a, \tau_a^*, \theta_H, \tau_b, \tau_b^*, \gamma) = \gamma V(\tau_{aH}, \tau_{aH}^*, \theta_H, \tau_b, \tau_b^*) + (1-\gamma)V(\tau_{aH}, \tau_{aL}^*, \theta_H, \tau_b, \tau_b^*)$. Home's expected welfare before the state is revealed is given as $EV^S(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*, \gamma) = \lambda V^S(\tau_a, \tau_a^*, \theta_H, \tau_b, \tau_b^*, \gamma) + (1-\lambda)V^S(\tau_a, \tau_a^*, \theta_L, \tau_b, \tau_b^*, \gamma)$. We make the same notation additions to Foreign, joint, and social welfare.

We again look for tariffs that solve a Nash bargaining problem where the countries have equal bargaining power. The incentive-unconstrained optimal same-sector probabilistic retaliation mechanism tariffs are:

$$\tau_b^{SP} = \tau_b^{*SP} = \tau_{aL}^{SP} = \tau_{aL}^{*SP} = 0 < \tau_{aH}^{*S} = \tau_{aH}^{SP} = \frac{(\theta_H - 1)(2A + 2Df - 3f)}{(D-2)(\theta_H - 5 - 4\gamma - 4D\gamma)}. \tag{23}$$

where the superscript "S" represents "same-sector" and the superscript "P" denotes "probabilistic".

5.B Cross-sector Probabilistic Retaliation

In the high state, with probability γ, Foreign is allowed to retaliate, but only in sector b. With probability $1-\gamma$ Foreign is not permitted to retaliate. Whether or not Foreign retaliates, Foreign maintains its low-state tariff in sector a (so that $\tau_{aH}^* = \tau_{aL}^*$) and Home maintains their low-state tariff in sector b (so that $\tau_{bH} = \tau_{bL}$). Hence, we have $V^C(\tau_a, \tau_a^*, \theta_H, \tau_b, \tau_b^*, \gamma) = \gamma V(\tau_{aH}, \tau_{aL}^*, \theta_H, \tau_{bL}, \tau_{bH}^*) + (1-\gamma)V(\tau_{aH}, \tau_{aL}^*, \theta_H, \tau_{bL}, \tau_{bL}^*)$ and, as in the same-sector case we make the necessary extensions to the low-state, expected, Foreign, joint, and social welfare. Using the superscripts "C" for "cross-sector" and "P" for "probabilistic", the incentive-unconstrained optimal cross-sector probabilistic retaliation tariffs are:

$$\tau_{bL}^{CP} = \tau_{bL}^{*CP} = \tau_{aL}^{CP} = \tau_{aL}^{*CP} = \tau_{bH}^{CP} = \tau_{aH}^{*CP} = 0 < \tau_{bH}^{*CP} = \tau_{aH}^{CP} = \frac{(\theta_H - 1)(2A + 2Df - 3f)}{(D-2)(\theta_H - 5 - 4\gamma)}. \tag{24}$$

Note that τ_{aH}^{SP} and τ_{aH}^{CP} are both decreasing in γ (a lower probability of permitted retaliation generates larger high-state tariffs) and as $\gamma = 1$, they converge to τ_{aH}^S and τ_{aH}^C as derived in section 4.[22]

5.C Welfare Comparisons

We now compare the incentive-unconstrained probabilistic tariffs and the efficient tariff.

Proposition 10. *For any given $\gamma \in (0, 1]$, when considering the joint political-welfare-maximizing incentive-unconstrained negotiated import tariffs under cross-sector and same-sector probabilistic retaliation mechanisms:*

(i) $\tau_{aH}^{SP} < \tau_{aH}^{CP} < \tau_{aH}^E$.

[22]The upper bound on θ_H so that Foreign will choose to take the full allowed retaliation is $\theta_H < \frac{6A+AD+4f(\gamma\text{-}1)+Df(2+D+2\gamma-2D\gamma)}{6A+AD-8f+4Df+D^2f}$ for same-sector retaliation and $\theta_H < \frac{12A+f(-8+7D+8\gamma-4D\gamma)}{12A+(-16+11D)f}$ for cross-sector retaliation. Noting that $A > 2f$ and $D < 1$ shows that the cross-sector upper bound is lower and, therefore, $\bar{\theta}^{FR}(A, f, D, \gamma) = \frac{12A+f(-8+7D+8\gamma-4D\gamma)}{12A+(-16+11D)f}$. As A approaches $2f$ and D approaches 0 this expression attains its supremum of $2 + \gamma$ as noted in footnote 13.

(ii) joint political welfare is greater under a cross-sector probabilistic retaliation mechanism and joint social welfare is greater under a same-sector retaliation mechanism;

(iii) if given the choice ex-post Foreign will retaliate cross-sector, but Foreign political and social welfare is greater if restricted ex-ante to same-sector retaliation.

The results in Proposition 10 are not surprising. They simply extend the results from Propositions 6, 7, and 8 to the case of an exogenous probability of retaliation. They do not take into account that the incentive constraints may bind at different values of γ so that the optimal probability of cross- and same-sector retaliation will differ. We now explicitly consider these constraints.

5.D Incentive-Constrained Welfare Comparisons

In this section we show that political welfare under either mechanism is maximized when the probability of retaliation is chosen so that the low-state incentive constraints bind with equality. We then compare maximum welfare under both mechanisms.

When Home is in a high-state it has no incentive to misrepresent the state and, therefore, the incentive constraints for the high state do not bind for any value of γ. On the other hand those for the low state are not satisfied for $\gamma = 0$ and are slack when $\gamma = 1$. Since these constraints are smooth functions of γ there is a value of γ at which each low-state constraint binds. As the following lemma shows political welfare for either mechanism is strictly decreasing in γ. Hence, the optimal probability of retaliation for each mechanism is the smallest one that satisfies the incentive constraints.

Lemma 2. *Joint political welfare under either the same-sector or cross-sector probabilistic retaliation mechanism is monotonically decreasing in $\gamma \in [0, 1]$.*

A reduction in the probability of retaliation increases the high-state tariff and moves it closer to the efficient level. This fact along with the reduced probability of retaliation generates an increase in political welfare. Of course, there is no reason to expect that the optimal probability of retaliation is the same for the two mechanisms. Since the probability of retaliation permitted by the WTO may differ under same- and cross-sector retaliation the assumption that they are chosen optimally guarantees that although different they are each chosen in the same manner. We write each of these minimal binding probabilities as γ^S and γ^C (their derivations are in our online appendix, [14]), we denote $E\Omega^C(\gamma^C, \theta)$ and $E\Omega^S(\gamma^S, \theta)$ as political joint welfare under each mechanism when the optimal high-state tariffs are a function of the binding incentive constraints and, we let $E\Omega^{UC}(\gamma^C, \theta)$ and $E\Omega^{US}(\gamma^S, \theta)$ similarly describe social welfare. We can now state our main result.

Proposition 11. *(i)* $E\Omega^C(\gamma^C, \theta) > E\Omega^S(\gamma^S, \theta)$.

(ii) $E\Omega^{UC}(\gamma^C, \theta) < E\Omega^{US}(\gamma^S, \theta)$.

In the proof to this proposition we show that $\gamma^C < (1+D)\gamma^S$, which implies that $\tau^{CP}_{aH}(\gamma^C) > \tau^{SP}_{aH}(\gamma^S)$. Hence, the intuition behind this result is the same as that noted above for the incentive-unconstrained case. The high-state tariffs are second best and they are lower than the politically optimal tariffs that would be realized without an information-revelation constraint. This higher tariff effect works together with the strategic effect in the political welfare case and against it in the social welfare case. As in Propositions 7 and 10, if given the choice ex-post, then Foreign would prefer cross-sector retaliation and since the proof and intuition for this result is the same as that contained in the previous propositions it is omitted. In the next section we consider the question of whether countries would agree to either mechanism in the first place and if our results still obtain when we consider the voluntary participation constraints.

6 Dynamic Setup: "Off-schedule" Violations

We now analyze if countries will adhere to the trade agreement. If a country chooses a tariff that is not permitted by the mechanism or if Home does not give the per-period side payment, then it is an "off-schedule" violation. To deter such violations, we consider history-dependent strategies. Following Bagwell and Staiger [7], we use infinite Nash reversion as the punishment for this type of violation. These grim-trigger strategies specify that if either country commits an off-schedule violation, then the other country will punish them by imposing the Nash tariff in both sectors forevermore. As shown in lemma 2 the welfare of both countries is decreasing in the probability of retaliation, therefore, welfare is greater in a probabilistic retaliation mechanism than in a non-probabilistic one. For that reason, we only focus on "off-schedule" violations in a probabilistic retaliation mechanism where the probability of retaliation is endogenously determined.

We first consider if Home will pay the side payment to Foreign in every period. Remember that the side payment is chosen before Home learns the current state and it is set to equalize Home and Foreign welfare. Home's expected welfare from paying the side payment for the cross- and same-sector mechanisms in any period s are $\sum_{t=s}^{\infty} \delta^{(t-s)}[EV^C(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*, \gamma^C) - \zeta_{CP}]$ and $\sum_{t=s}^{\infty} \delta^{(t-s)}[EV^S(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*, \gamma^S) - \zeta_{SP}]$, respectively. If Home does not give the side payment, then they receive the expected Bayes-Nash equilibrium payoff in the current and every future period $\sum_{t=s}^{\infty} \delta^{(t-s)}[EV^{BN}(\theta)]$. After substituting for the side payments and collecting terms we see that Home will give the required side payment in the cross-sector mechanism if $\frac{1}{2(1-\delta)}[E\Omega^C(\gamma^C,\theta)] \geq \frac{1}{2(1-\delta)}[E(V^{BN}(\theta))+EV^{*BN}(\theta)]$ which holds because the mechanism tariffs are chosen to maximize welfare in either state. A similar comparison holds for the same-sector mechanism. Hence, the side-payment voluntary participation constraint is satisfied under both mechanisms

We now consider the tariff. Since Home's welfare in either sector is decreasing in Foreign's tariff, if Home were to violate the agreement, then they would announce that political pressure is low (regardless of the true state) so that Foreign would choose a low-state tariff in the deviation period. Home's sector a optimal deviations are given by $\tau_{a\kappa t}^{Sd} = \underset{\tau_{at}}{\operatorname{argmax}} \quad \vartheta_a(\tau_{at}, \tau_{aL}^*, \theta_{\kappa t})$ for a same-sector mechanism and $\tau_{a\kappa t}^{Cd} = \underset{\tau_{at}}{\operatorname{argmax}} \quad \vartheta_a(\tau_{at}, \tau_{aL}^*, \theta_{\kappa t})$ for cross-sector, where we have used the fact that Foreign's low-state tariff is the same in either mechanism. Hence, the sector-a deviation tariffs are the same for either mechanism, $\tau_{a\kappa t}^{Cd} = \tau_{a\kappa t}^{Sd} = \tau_{a\kappa t}^{d} = \frac{(2A+2Df-3f)\theta_\kappa-2A-3Df+5f}{(7-\theta_\kappa)(2-D)}$, which is greater than either mechanism's high-state tariff (as shown in our online appendix). Home's sector b optimal deviation is the same for either mechanism, and does not depend on the state and is given by $\tau_b^d = \underset{\tau_b}{\operatorname{argmax}} \quad \vartheta_b(\tau_b, \tau_{bL}^*) = \frac{f}{6}$.

The voluntary participation constraints for the same- and cross-sector mechanisms in period s are:

$$\begin{aligned} &V^S(\tau_{as}, \tau_{as}^*, \theta_{\kappa s}, \tau_b, \tau_b^*, \gamma^S) + \sum_{t=s+1}^{\infty} \delta^{(t-s)}[EV^S(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*, \gamma^S) - \zeta_{SP}] \\ &\geq V(\tau_{a\kappa s}^d, \tau_{aL}^*, \theta_\kappa, \tau_b^d, \tau_{aL}^*) + \sum_{t=s+1}^{\infty} \delta^{(t-s)}[EV^{BN}(\theta)], \end{aligned} \tag{25}$$

$$\begin{aligned} &V^C(\tau_{as}, \tau_{as}^*, \theta_{\kappa s}, \tau_b, \tau_b^*, \gamma^C) + \sum_{t=s+1}^{\infty} \delta^{(t-s)}[EV^C(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*, \gamma^C) - \zeta_{CP}] \\ &\geq V(\tau_{a\kappa s}^d, \tau_{aL}^*, \theta_\kappa, \tau_b^d, \tau_{aL}^*) + \sum_{t=s+1}^{\infty} \delta^{(t-s)}[EV^{BN}(\theta)]. \end{aligned} \tag{26}$$

where we use the fact that Home would always announce a low state (and Foreign would levy the low tariff, which is the same in both sectors and in both mechanisms) in any deviation period. The right-hand side of equations (25) and (26) are identical. Hence, to compare the enforceability of the two mechanisms we only need to analyze the left-hand sides of the above equations. Note that the summand of the second expression on the left-hand side is $EV(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*, \gamma) - \zeta = \frac{E\Omega(\gamma,\theta)+EV^{BN}(\theta)-EV^{*BN}(\theta)}{2}$ which, by Proposition 11 is larger for the cross-sector mechanism. In addition, for the first term, both mechanisms only differ in the high state. As shown in the appendix $V^C(\tau_a, \tau_a^*, \theta_H, \tau_b, \tau_b^*, \gamma^C) > V^S(\tau_a, \tau_a^*, \theta_H, \tau_b, \tau_b^*, \gamma^S)$, therefore, the best incentive-compatible cross-sector mechanism can be supported for a wider range of discount factors.

Denoting δ^Cas the critical discount factor for the cross-sector mechanism and δ^Sas that for the same-sector one, we then have the following.

Proposition 12. *The same-sector probabilistic retaliation mechanism is self-enforcing for all $\delta \in [\delta^S, 1]$ and the cross-sector probabilistic retaliation mechanism is self-enforcing for all $\delta \in [\delta^C, 1]$, where $\delta^C < \delta^S < 1$.*

Proposition 12 shows that voluntary adherence to the mechanism can be more easily supported by the cross-sector mechanism. Although social welfare is enhanced by limiting retaliation to the same sector it may be more difficult to enforce adherence to an agreement that prohibits cross-sector retaliation. For example, the infinitely repeated game with discount factor, δ, can be considered as a finitely repeated game with a constant, and common knowledge, hazard rate that the game continues. In this interpretation $\delta = he^{-\rho L}$, where h is the hazard rate that the trade relationship continues, ρ is the rate of time preference, and L is the period length. Staiger [33] (pp. 1520-1521) explains that the period length can be thought of as the time required for observing and responding to the trading partner's policies. Domestic or international shocks, political or otherwise, can affect all of these parameters and a cross-sector mechanism is self-enforcing through a greater range of such shocks.

7 Export Lobbies

In this section we extend our model to include political pressure in Home's exporting industries, x_a and x_b, and we use the term export lobbies to describe this pressure. As a result of these lobbies, Home political welfare attaches weights $\chi_a \in [1, \theta_H)$ and $\chi_b \in [1, \theta_H)$ to numeraire consumption provided by profits in these industries. The per-period political welfare of Home in each sector is defined as:

$$\begin{aligned}\vartheta_{at}(\tau_{at}, \tau_{at}^*, \theta_{\kappa t}, \chi_a) = & \int_{p_{x_a t}(\tau_{at}^*)}^{A} \int_{p_{y_a t}(\tau_{at})}^{A} u_{at}[q_{x_a t}^d, q_{y_a t}^d] dp_{x_a t} dp_{y_a t} + \chi_a \int_0^{p_{x_a t}(\tau_{at}^*)} q_{x_a t}^s dp_{x_a t} \\ & + \theta_{\kappa t} \int_f^{p_{y_a t}(\tau_{at})} q_{y_a t}^s dp_{y_a t} + \tau_{at}[q_{y_a t}^d - q_{y_a t}^s],\end{aligned}$$

$$\begin{aligned}\vartheta_{bt}(\tau_{bt}, \tau_{bt}^*, \chi_b) = & \int_{p_{x_b t}(\tau_{bt}^*)}^{A} \int_{p_{y_b t}(\tau_{bt})}^{A} u_{bt}[q_{x_b t}^d, q_{y_b t}^d] dp_{x_b t} dp_{y_b t} + \chi_b \int_0^{p_{x_b t}(\tau_{bt}^*)} q_{x_b t}^s dp_{x_b t} \\ & + \int_f^{p_{y_b t}(\tau_{bt})} q_{y_b t}^s dp_{y_b t} + \tau_{bt}[q_{y_b t}^d - q_{y_b t}^s].\end{aligned}$$

For tractability we assume that these export lobby weights do not fluctuate over time. We also continue to assume that the weight on the import-competing industry, y_b, in sector b is unity. As will be shown below, the key distinction is between export lobbies in the same sector as the fluctuating θ (i.e. χ_a) or in the other sector (i.e. χ_b). Hence, relaxing the assumption of a unity weight on import-competing profits in the other sector would not affect our results. Since Foreign does not face any political pressure in either import-competing industry we continue to assume that they have none in either export industry. Home per-period political welfare can then be written as $V(\tau_a, \tau_a^*, \theta_\kappa, \chi_a, \chi_b, \tau_b, \tau_b^*, \gamma)$, expected joint political welfare as $E\Omega(\gamma, \theta, \chi_a, \chi_b)$, and expected joint social welfare as $E\Omega^U(\gamma, \theta, \chi_a, \chi_b)$.

The high-state same-sector and cross-sector mechanism tariffs are again chosen as the solution to a Nash-bargaining problem whereby home gives a side payment, that equalizes the expected gains from the agreement, to Foreign before the state is revealed. These tariffs are derived as:

$$\begin{aligned}\tau_{aH}^{SPx} &= \frac{(\theta_H - 1)(2A - 3f + 2Df) + \gamma^S(2A + f)(1 - \chi_a)}{(2 - D)(5 - \theta_H + \gamma^S(5 - \chi_a + 4D))}, \\ \tau_{aH}^{CPx} &= \frac{(\theta_H - 1)(2A - 3f + 2Df) + \gamma^C(2A + f)(1 - \chi_b)}{(2 - D)(5 - \theta_H + \gamma^C(5 - \chi_b))}.\end{aligned} \tag{27}$$

It is straight forward to verify that if $\chi_a = \chi_b = 1$, then these tariffs converge to the probabilistic tariffs from section 5 and if, in addition $\gamma^S = \gamma^C = 1$, then they converge to the deterministic tariffs from section 4.[23] The non-negativity constraint provides low-state tariffs of zero.[24]

Although the cross-sector tariffs are only a function of χ_b and the same-sector ones are only a function of χ_a, welfare in each mechanism is a function of both of these variables, which adds additional complexity to the analysis. As will be seen below one source of the complexity is that the export-oriented political pressure in sector a and sector b have opposing effects.

We start by considering the simplest case, whereby $\chi_a = \chi_b = \chi$ and $\gamma^C = \gamma^S = 1$. In this case, we have that

[23] The critical values of θ so that imports are positive and that Foreign will use the full allowed retaliation are given as $\theta_H < \frac{A(6+D)(1+\gamma^S(\chi_a-1))+f(2\gamma^S(1+\chi_a)-4)+Df((2+\gamma^S(1+\chi_a)+D(1-2D\gamma^S))}{6A+AD-8f+4Df+D^2f}$ for same-sector retaliation and $\theta_H < \frac{12A(1+\gamma^C(\chi_b-1)+f(-8+4\gamma^C(1+\chi_b)+fD(7+\gamma^C(\chi_b-5))}{12A+(-16+11D)f}$ for cross-sector retaliation. These upper bounds are increasing in χ_a and χ_b, respectively, and when $\chi_a = \chi_b = 1$ and $\gamma^C = \gamma^S = \gamma$ they converge to the upper bounds on θ reported in footnote 23.

[24] In the absence of the no-negative tariffs constraint the jointly optimal Foreign low-state tariff would be negative when Home has export-sector political pressure. We also solved the model without this constraint and although the derivation is more complicated, the direction of the results do not differ from the version we provide here. In particular, because our focus is the comparison between same- and cross-sector retaliation the choice of the low-state (and base level for the high-state) tariffs does not significantly affect this comparison.

$$
\begin{aligned}
&E\Omega^S(\theta,\chi) - E\Omega^C(\theta,\chi)\\
=&\frac{-\lambda D[2A(\theta_H-\chi) - f(3\theta_H+\chi-4) + 2Df(\theta_H-1)]^2}{2(2-D)^2(10-\chi-\theta_H)(10-\chi-\theta_H+4D)} < 0\\
&E\Omega^{US}(\theta,\chi) - E\Omega^{UC}(\theta,\chi)\\
=&\frac{\lambda D[2A(\theta_H-\chi) - f(3\theta_H+\chi-4) + 2Df(\theta_H-1)]^2[32D - (-10+\chi+\theta_H)(6+\chi+\theta_H)]}{2(2-D)^2(10-\chi-\theta_H)^2(10-\chi-\theta_H+4D)^2} > 0.
\end{aligned}
\tag{28}
$$

Hence, the inclusion of export lobbies that exert the same pressure in both sectors does not change our results, at least when retaliation is deterministic. It is straightforward to verify that when $\chi = 1$ the expressions in equations (28) converge to those in the proofs of propositions 6 and 7.

The more interesting cases are when there are differences between the export lobbies in each sector. To perform this analysis we consider changes in either χ_a or χ_b when $\gamma^C = \gamma^S = \gamma$. As shown in the appendix these changes can be signed as $\frac{\partial[E\Omega^S(\gamma,\theta,\chi_a,\chi_b) - E\Omega^C(\gamma,\theta,\chi_a,\chi_b)]}{\partial\chi_b} > 0$ and $\frac{\partial[E\Omega^S(\gamma,\theta,\chi_a,\chi_b) - E\Omega^C(\gamma,\theta,\chi_a,\chi_b)]}{\partial\chi_a} < 0$. These effects are reversed for social welfare. We establish these results in the following proposition.

Proposition 13. *If there are welfare weights $\chi_a \in [1, \theta_H)$ and $\chi_b \in [1, \theta_H)$ on numeraire consumption provided by profits in Home's export industries, and if the probability of retaliation is the same for either mechanism ($\gamma^C = \gamma^S = \gamma$), then an increase in χ_a (χ_b) increases (reduces) the joint political-welfare advantage of cross-sector over same-sector retaliation. An increase in χ_a (χ_b) increases (reduces) the joint social-welfare advantage of same-sector over cross-sector retaliation.*

There are two opposing effects described in proposition 13. The first effect is that of an increase in export lobbies in sector a (the same sector as the import-competing sector with high political pressure). This effect reinforces our previous results since it further increases the political welfare benefit of cross-sector retaliation and also the social-welfare benefit of same-sector retaliation. The second effect is more interesting because export lobbies in sector b provide a limitation on our previous results: opposite sector export lobbies reduce the political welfare benefit of cross-sector retaliation. The intuition here is provided by considering equation (27). It is straightforward to verify that these tariffs are decreasing in the export lobby political pressure (exporters do not want high retaliatory tariffs). Hence, sector b export lobbies generate lower cross-sector retaliation tariffs and these tariffs are now further from the efficient level so that same-sector retaliation provides greater political (but lower social) welfare.

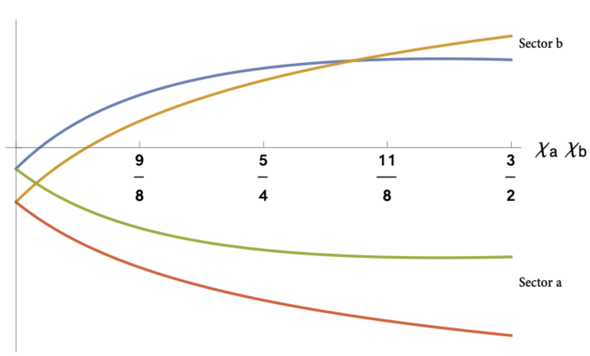
The welfare differences described in proposition 13 are monotonic in χ_b, therefore, there exists an $\hat{\chi}_b$ such that for all $\chi_b > \hat{\chi}_b$ political welfare would be greater with same-sector retaliation and social welfare would be larger with cross-sector retaliation. Hence, for $\chi_b > \hat{\chi}_b$ our main results in propositions 6 and 10 would be reversed. It is, therefore, important to examine how large is the critical $\hat{\chi}_b$ especially in comparison to θ_H.

Before examining $\hat{\chi}_b$ we note the following. Foreign political welfare equals its social welfare and is one-half of world social welfare. Hence, if $\chi_b > \hat{\chi}_b$, then Foreign would have greater political and social welfare if cross-retaliation is permitted. This last case is opposite the result in propositions 8 and 10. As always, Foreign would choose cross-retaliation ex-post if it was available, but if $\chi_b > \hat{\chi}_b$, then Foreign would now be glad that they had that choice ex-ante. On the other hand, since world political welfare (but not Foreign's) would be greater with same-sector retaliation, Home's political welfare would be worse under cross-sector retaliation. We state this potential reversal of corollary 1 below.

Corollary 2. *If $\chi_b > \hat{\chi}_b$, then joint political welfare and Home's political welfare are both maximized by not allowing Foreign to choose the sector of retaliation.*

To have a better idea of the critical $\hat{\chi}_b$ as well as the magnitude of the changes described in proposition 13 we parameterize our model and we assume that the export lobbies are only active in one sector, so that either $\chi_a = 1$ or $\chi_b = 1$. We start by setting $A = 3$, $f = 1$, $D = \frac{1}{2}$ and $\theta_H = \frac{5}{4}$ and we vary these parameters to analyze their affect on $\hat{\chi}_b$. We also set γ^C and γ^S at their optimal binding values. The difference in political welfare, $E\Omega^S(\gamma^S, \theta, \chi_a, \chi_b) - E\Omega^C(\gamma^C, \theta, \chi_a, \chi_b)$, is graphed in Figure 7. The two convex curves show the effect of export lobbies active only in sector a (so that $\chi_b = 1$). These curves remain below the horizontal axis, therefore, as shown in proposition 13, sector a export lobbies do not change the previous results. The difference in the two convex curves is that the one closest to the horizontal axis has $\theta_H = \frac{5}{4}$ and the one further away sets $\theta_H = \frac{11}{8}$.

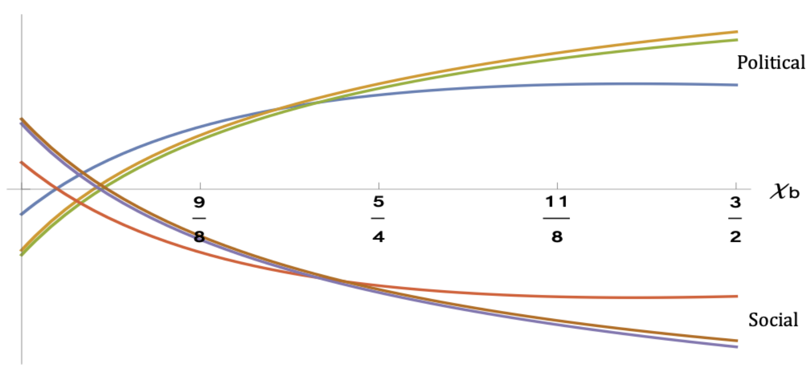
Figure 7: $E\Omega^S(\gamma^S, \theta, \chi_a, \chi_b) - E\Omega^C(\gamma^C, \theta, \chi_a, \chi_b)$



The more interesting case is when export lobbies are only active in sector b (so that $\chi_a = 1$). The effect of χ_b is shown in the two concave curves and as χ_b increases from unity we see that there is a critical value of $\hat{\chi}_b < \theta_H$ such that for $\chi_b > \hat{\chi}_b$ the same-sector retaliation mechanism generates greater joint political welfare. It is again the case that the curve closest to the horizontal axis uses $\theta_H = \frac{5}{4}$ so that when θ_H increases (to $\frac{11}{8}$) the critical $\hat{\chi}_b$ that generates a reversal becomes greater.

In figure 8 we examine how changes in the other parameters affect the critical value of $\hat{\chi}_b$ and also how χ_b affects social welfare. The three concave curves illustrate the effect of opposite sector export lobbies, χ_b, on political welfare. The concave curve with the highest vertical axis intercept was also shown in Figure 7, where we set $A = 3$, $f = 1$, $D = 1/2$ and $\theta_H = \frac{5}{4}$. The next highest curve increases A to 4 and the lowest sets $A = 3$ but changes D to $\frac{3}{4}$. Hence, larger values of A, D, or θ (as shown in Figure 7) increase the minimum required level of $\hat{\chi}_b$ so that political welfare becomes greater with same-sector retaliation. Still, in all cases the critical $\hat{\chi}_b$ is much less than θ_H and is quite close to unity, therefore, a modest amount of export lobby pressure can reverse the political welfare advantage of cross-sector retaliation.

Figure 8: $E\Omega^S(\gamma^S, \theta, 1, \chi_b) - E\Omega^C(\gamma^C, \theta, 1, \chi_b)$ and $E\Omega^{US}(\gamma^S, \theta, 1, \chi_b) - E\Omega^{UC}(\gamma^C, \theta, 1, \chi_b)$



The three convex curves in Figure 8 show the effect of sector b export lobbies on social welfare and they are the mirror images of the effect on political welfare. The critical $\hat{\chi}_b$ so that social welfare becomes greater under cross-sector retaliation is exactly the same at which same-sector retaliation generates greater political welfare.[25]

[25]Same-sector export lobbies, χ_a also exhibit symmetric effects on political and social welfare. Since, they do not change any of our previous results, they are less interesting and are not shown here. In particular, larger values of χ_a reduce same sector tariffs so that political welfare is further enhanced and social welfare is increasingly reduced by cross-sector retaliation.

8 Conclusion

In this paper, we analyze the WTO's preference for same-agreement retaliation when the disputing parties are of similar economic size. Our analysis is built on the strategic substitutability of tariffs and incomplete information of political pressure. Still, cross-agreement retaliation may be limited for other reasons. First, a temporary suspension of concessions in TRIPS may violate the intellectual property obligations agreed to in the Paris (1967) and Berne (1971) conventions. As Subramanian and Watal [34] note, however, the Vienna (1969) convention indicates that the TRIPS and WTO agreements signed at a later date would take precedence.[26] Second, Maggi [28] considers the idea that linking is limited in practice because contracting and transaction costs may be convex in the number of issues, courts have limited capacity, there are diseconomies of scope in judicial activities, or linking may require coordination of differing groups of experts. He argues, however, that there is no evidence on contracting cost convexity and that there is no reason that courts (and experts) need to be fully integrated even if issues are linked.

One possible normative implication from our results is that if the WTO or PTA authority considers political welfare as the valid metric, then it should encourage cross-retaliation (at least within an agreement, unless export-oriented lobbies are strong). On the other hand, if they consider social welfare as the correct measure, then (given the respondent's preference for cross-retaliation) they may wish to restrict the ability to cross retaliate (while recognizing that allowing for cross-retaliation would relax the enforcement constraint). Given the stylized and symmetric nature of our model it is not intended to directly influence policy. Still, it suggests that further research into the relative magnitudes of strategic substitutability within and across sectors and agreements can help guide further decisions.

An additional question raised by these opposing normative implications is the relative influence of political and social welfare in guiding the design and decisions of the WTO and the various PTAs. Finally, it suggests that in cases where social welfare is more important, there is an important trade off between negotiation efficiency and enforcement capability. In particular, the self-enforcement constraint (which depends on the sentiments of the signatory governments) is more easily satisfied by the mechanism that generates greater political welfare.

[26] Abbott [1], pages 13-18, provides a detailed legal examination of why intellectual property cross retaliation in either the WTO or PTAs would be allowed by the international court of justice. He argues that it is not merely that TRIPS is signed at a later date, but that a good faith adherence to the agreement of the WTO and DSU implies acceptance of the possibility of cross retaliation without recourse to the Paris or Berne conventions. Subramanian and Watal [34] and Abbott [1] also consider several scenarios in which retaliation in TRIPS could be practical and effective.

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Appendix

Lemma 1. *If the utility functions are as given in equation (1) and the cost functions are as given in equation (2), then the following results hold.*

(i) *The per-period political welfare in each sector is strictly concave in the domestic tariff and, for a domestic tariff in the neighborhood of zero, it is strictly increasing in the domestic tariff. It is strictly convex and monotonically decreasing in the foreign tariff.*

(ii) *The within-sector best-response tariffs are strategic substitutes.*

(iii) *For all $\theta \in [1, \bar{\theta})$ there is a unique Nash equilibrium in tariffs.*

(iv) *For all $\lambda \in [0, 1]$ there is a unique Bayes-Nash equilibrium in tariffs.*

Proof. (i) Since our analysis is confined to a one-period game, we can drop the subscript t. Given that trade is balanced in equilibrium (that is, $q^s_{y_a} - q^d_{y_a} = q^{*d}_{y_a} - q^{*s}_{y_a}$ and $q^{*s}_{x_a} - q^{*d}_{x_a} = q^d_{x_a} - q^s_{x_a}$) and using the demand and supply functions in equations (3) and (4), we have

$$\begin{aligned} p_{x_a} &= -\frac{1}{2}\tau^*_a + \frac{2A+f}{4-2D}; \quad p_{y_a} = \frac{1}{2}\tau_a + \frac{2A+f}{4-2D}; \\ p^*_{x_a} &= \frac{1}{2}\tau^*_a + \frac{2A+f}{4-2D}; \quad\;\; p^*_{y_a} = -\frac{1}{2}\tau_a + \frac{2A+f}{4-2D}, \end{aligned} \tag{29}$$

and

$$\begin{aligned} q^d_{x_a} &= \frac{1}{2}D\tau_a + \frac{1}{2}\tau^*_a + \frac{2A+f(D-1)}{4-2D}; \quad q^d_{y_a} = -\frac{1}{2}\tau_a - \frac{1}{2}D\tau^*_a + \frac{2A+f(D-1)}{4-2D}; \\ q^{*d}_{x_a} &= -\frac{1}{2}\tau^*_a - \frac{1}{2}D\tau_a + \frac{2A+f(D-1)}{4-2D}; \quad q^{*d}_{y_a} = \frac{1}{2}D\tau^*_a + \frac{1}{2}\tau_a + \frac{2A+f(D-1)}{4-2D}; \\ q^s_{x_a} &= -\frac{1}{2}\tau^*_a + \frac{2A+f}{4-2D}; \quad q^s_{y_a} = \frac{1}{2}\tau_a + \frac{2A-3f+2Df}{4-2D}; \\ q^{*s}_{x_a} &= \frac{1}{2}\tau^*_a + \frac{2A-3f+2Df}{4-2D}; \quad q^{*s}_{y_a} = -\frac{1}{2}\tau_a + \frac{2A+f}{4-2D}. \end{aligned} \tag{30}$$

Note that the per period indirect utility function of home in sector a is defined as follows:

$$\begin{aligned} &\vartheta_a(\tau_a, \tau^*_a, \theta_\kappa) \\ &= u[q^d_{x_a}(p_{x_a}, p_{y_a}), q^d_{y_a}(p_{y_a}, p_{x_a})] - p_{x_a}(\tau^*_a)q^d_{x_a}(p_{x_a}, p_{y_a}) - p_{y_a}(\tau_a)q^d_{y_a}(p_{y_a}, p_{x_a}) \\ &+ p_{x_a}(\tau^*_a)q^s_{x_a}(p_{x_a}) - c_{x_a}(q^s_{x_a}(p_{x_a})) + \theta_\kappa[p_{y_a}(\tau_a)q^s_{y_a}(p_{y_a}) - c_{y_a}(q^s_{y_a}(p_{y_a}))] \\ &+ \tau_a[q^d_{y_a}(p_{y_a}, p_{x_a}) - q^s_{y_a}(p_{y_a})] \\ &= \frac{1}{1-D^2}[\frac{1}{2}(q^d_{x_a})^2 + \frac{1}{2}(q^d_{y_a})^2 + Dq^d_{x_a}q^d_{y_a}] + \frac{1}{2}p^2_{x_a} + \frac{1}{2}\theta_H(p_{y_a} - f)^2 + \tau_a(q^d_{y_a} - q^s_{y_a}). \end{aligned}$$

Using equations (29) and (30) we then have that

$$
\begin{aligned}
\vartheta_a(\tau_a,\tau_a^*,\theta_H) = &\frac{\Upsilon^2}{1-D^2} + \frac{1}{2}\Upsilon(\tau_a^*-\tau_a) + \frac{1}{8}\tau_a^2 + \frac{1}{4}(\tau_a^*)^2 + \frac{1}{4}D\tau_a\tau_a^* + \frac{1}{2}\Psi^2 - \frac{1}{2}\tau_a^*\Psi \\
&+ \frac{1}{8}\theta_H\tau_a^2 + \frac{1}{2}\theta_H\tau_a(\Psi-f) + \frac{1}{2}\theta_H(\Psi-f)^2 + \tau_a(\Upsilon-\Psi+f) - \tau_a^2 - \frac{1}{2}D\tau_a\tau_a^*,
\end{aligned} \tag{31}
$$

where $\Upsilon = \frac{2A+f(D-1)}{4-2D}$ and $\Psi = \frac{2A+f}{4-2D}$. Taking the partial derivative of ϑ_a with respect to τ_a, using the first order conditions from the producer and consumer maximization problem and the Envelope Theorem and plugging equation (4) into it, along with equation (29), which implies that $\frac{\partial p_{y_a}}{\partial \tau_a} = \frac{1}{2}$, yields

$$
\frac{\partial \vartheta_a(\tau_a,\tau_a^*,\theta_\kappa)}{\partial \tau_a} = (\frac{1}{2}\theta_\kappa - 1)(p_{y_a}-f) + \frac{1}{2}q_{y_a}^d(p_{y_a},p_{x_a}) - \tau_a. \tag{32}
$$

By following similar arguments, we have

$$
\begin{aligned}
&\frac{\partial \vartheta_a(\tau_a,\tau_a^*,\theta)}{\partial \tau_a^*} = -\frac{1}{2}M_a^* - \frac{1}{2}D\tau_a; \quad \frac{\partial \vartheta_i^*(\tau_i^*,\tau_i)}{\partial \tau_i^*} = \frac{1}{2}M_i^* - \tau_i^*; \\
&\frac{\partial \vartheta_i^*(\tau_i,\tau_i^*)}{\partial \tau_i} = -\frac{1}{2}M_i^* - \frac{1}{2}D\tau_i^*; \quad \frac{\partial \vartheta_b(\tau_b,\tau_b^*)}{\partial \tau_b} = \frac{1}{2}M_b - \tau_b; \quad \frac{\partial \vartheta_b(\tau_b,\tau_b^*)}{\partial \tau_b^*} = -\frac{1}{2}M_b^* - \frac{1}{2}D\tau_b,
\end{aligned} \tag{33}
$$

where $M_a \equiv q_{y_a}^d(p_{y_a},p_{x_a}) - q_{y_a}^s(p_{y_a})$ and $M_i^* \equiv q_{x_i}^{d^*}(p_{x_i}^*,p_{y_i}^*) - q_{x_i}^{s^*}(p_{x_i}^*)$.

Therefore, we have $\frac{\partial \vartheta_i(\tau_i,\tau_i^*,\theta_\kappa)}{\partial \tau_i}|_{\tau_i=0} > 0$, $\vartheta_{i11} < 0, \vartheta_{i2} < 0$ and $\vartheta_{i22} > 0$. This completes the proof of part (i).

(ii) By using Eqs.(32) and (33), the best response functions for home and foreign are

$$
\begin{aligned}
\tau_{a\kappa}^R(\tau_a^*) &= \frac{(2Df+2A-3f)\theta_\kappa - 3Df - 2A + 5f + (D^2-2D)\tau_a^*}{(\theta_\kappa - 7)(D-2)}, \\
\tau_a^{*R}(\tau_a) &= -\frac{1}{6}D\tau_a + \frac{1}{6}f.
\end{aligned}
$$

Hence,

$$
\frac{\partial^2 \vartheta_i(\tau_i,\tau_i^*)}{\partial \tau_i^* \partial \tau_i} = -\frac{1}{4}D < 0
$$

so that the import tariffs within the sectors are strategic substitutes.

(iii) From part (i) we see that ϑ_{i1} and ϑ_{i1}^* are continuous in τ_i and τ_i^*, for all $\theta < \bar{\theta}$, by the Brouwer fixed point theorem, there exists a unique Nash equilibrium in tariffs:

$$
\begin{aligned}
\tau_{ak}^N &= \frac{D^2 f + (12f\theta_\kappa - 20f)D + (12A - 18f)\theta_\kappa - 12A + 30f}{(D-2)(D^2 + 6\theta_\kappa - 42)}, \\
\tau_{ak}^{*N} &= \frac{(-2f\theta + 3f)D^2 + (-2A\theta_\kappa + 4f\theta_\kappa + 2A - 12f)D - 2f(\theta_\kappa - 7)}{(D-2)(D^2 + 6\theta_\kappa - 42)}.
\end{aligned}
$$

(iv) From part (i) we also see that $\frac{\partial \vartheta_a^*(E(\tau_a),\tau_a^*)}{\partial \tau_a^*} = \frac{1}{2}E(M_a^*) - \tau_a^*$, which is continuous in τ_a^* and $E(\tau_a)$ where $E(\tau_a)$ and $E(M_a^*)$ are the expectation, with respect to θ, of imports and the Home tariff. Hence, by the Brouwer fixed point theorem, there exists a unique Bayes-Nash equilibrium in tariffs:

$$\tau_{aH}^{BN} = \frac{2A[36+D^2(\lambda-1)](\theta-1)+f[36(5-3\theta)+24D(-5+3\theta)+3D^2(1+\lambda+\theta-\lambda\theta)+2D^3(\lambda-1)(\theta-1)]}{(D-2)D^2(7+\lambda(\theta-1)-\theta)+36(\theta-7)]},$$
$$\tau_{aL}^{BN} = \frac{2AD^2\lambda(\theta-1)+f[(12-8D)(7-\theta)+D^2(7+3\lambda-\theta-3\lambda\theta)+2D^3\lambda(\theta-1)]}{(D-2)D^2(7+\lambda(\theta-1)-\theta)+36(\theta-7)]},$$
$$\tau_a^{*BN} = \frac{-12AD\lambda(\theta-1)+f[(12-8D)(7-\theta)+16D\lambda(\theta-1)+D^2(7+11\lambda-\theta-11\lambda\theta)]}{(D-2)D^2(7+\lambda(\theta-1)-\theta)+36(\theta-7)]}.$$

□

Proposition 1. *The joint political-welfare-maximizing tariffs under perfect information are*

$$\tau_{aL}^e = \tau_{aL}^{*e} = \tau_b^e = \tau_b^{*e} = 0;$$

$$\tau_{aH}^{*e} = -\frac{D}{2}\frac{(\theta_H-1)(2Df-3f+2A)}{(2-D)(5-\theta_H-D^2)} < 0 < \tau_{aH}^e = \frac{(\theta_H-1)(2Df+2A-3f)}{(2-D)(5-\theta_H-D^2)}.$$

Proof. Let $\eta_e = \lambda[EV(\tau_a,\tau_{aH}^*,\theta_H,\tau_b,\tau_b^*)-V^N(\theta_H)]+(1-\lambda)[V(\tau_{aL},\tau_{aL}^*,\theta_L,\tau_b,\tau_b^*)-V^N(\theta_L)]$ and $\eta_e^* = \lambda[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)-V^{*N}(\theta_H)]+(1-\lambda)[V^*(\tau_{aL},\tau_{aL}^*,\tau_b,\tau_b^*)-V^{*N}(\theta_L)]$. The first-order-conditions from the Nash-bargaining problem

$$\max_{\tau_{aH},\tau_{aH}^*,\tau_{aL},\tau_{aL}^*,\tau_b,\tau_b^*}\{(\lambda[V(\tau_{aH},\tau_{aH}^*,\theta_H,\tau_b,\tau_b^*)-V^N(\theta_H)]+(1-\lambda)[V(\tau_{aL},\tau_{aL}^*,\theta_L,\tau_b,\tau_b^*)-V^N(\theta_L)]-\zeta_E)$$
$$\times(\lambda[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)-V^{*N}(\theta_H)]+(1-\lambda)[V^*(\tau_{aL},\tau_{aL}^*,\tau_b,\tau_b^*)-V^{*N}(\theta_L)]+\zeta_E)\}$$

can then be written as

$$\begin{aligned}
\lambda\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_H,\tau_b,\tau_b^*)}{\partial\tau_{aH}}(\eta_e^*+\zeta_e)+\lambda\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_{aH}}(\eta_e-\zeta_e)=0;\\
\lambda\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_H,\tau_b,\tau_b^*)}{\partial\tau_{aH}^*}(\eta_e^*+\zeta_e)+\lambda\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_{aH}^*}(\eta_e-\zeta_e)=0;\\
(1-\lambda)\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_L,\tau_b,\tau_b^*)}{\partial\tau_{aL}}(\eta_e^*+\zeta_e)+(1-\lambda)\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_{aL}}(\eta_e-\zeta_e)=0;\\
(1-\lambda)\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_L,\tau_b,\tau_b^*)}{\partial\tau_{aL}^*}(\eta_e^*+\zeta_e)+(1-\lambda)\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_{aL}^*}(\eta_e-\zeta_e)=0;\\
\lambda\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_H,\tau_b,\tau_b^*)}{\partial\tau_b}(\eta_e^*+\zeta_e)+\lambda\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_b}(\eta_e-\zeta_e)\\
+(1-\lambda)\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_L,\tau_b,\tau_b^*)}{\partial\tau_b}(\eta_e^*+\zeta_e)+(1-\lambda)\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_b}(\eta_e-\zeta_e)=0;\\
\lambda\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_H,\tau_b,\tau_b^*)}{\partial\tau_b^*}(\eta_e^*+\zeta_e)+\lambda\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_b^*}(\eta_e-\zeta_e)\\
+(1-\lambda)\frac{\partial[V(\tau_{aH},\tau_{aH}^*,\theta_L,\tau_b,\tau_b^*)}{\partial\tau_b^*}(\eta_e^*+\zeta_e)+(1-\lambda)\frac{\partial[V^*(\tau_{aH},\tau_{aH}^*,\tau_b,\tau_b^*)}{\partial\tau_b^*}(\eta_e-\zeta_e)=0.
\end{aligned}$$

Since $\zeta_e = (\lambda[V(\tau_{aH}, \tau^*_{aH}, \theta_H, \tau_b, \tau^*_b) - V^N(\theta_H) - V^*(\tau_{aH}, \tau^*_{aH}, \tau_b, \tau^*_b) + V^{*N}(\theta_H)] + (1-\lambda)[V(\tau_{aL}, \tau^*_{aL}, \theta_L, \tau_b, \tau^*_b) - V^N(\theta_L) - V^*(\tau_{aL}, \tau^*_{aL}, \tau_b, \tau^*_b) + V^{*N}(\theta_L)])/2$ it is straightforward to verify that $\eta^*_e + \zeta_e = \eta_e - \zeta_e$. Hence, the solution to the first first-order-condition above is equivalent to the solution of $\frac{\partial[V(\tau_{aH}, \tau^*_{aH}, \theta_H, \tau_b, \tau^*_b)}{\partial \tau_{aH}}) + \frac{\partial[V^*(\tau_{aH}, \tau^*_{aH}, \tau_b, \tau^*_b)}{\partial \tau_{aH}} = 0$, which is equivalent to the solution of $\frac{\partial E\Omega(\theta)}{\partial \tau_{aH}} = 0$. A similar result obtains for all remaining first-order-conditions.

Using the fact that each country's welfare is separable in the sectors and that the state is revealed before tariffs are chosen we can look for the solutions to equations (8 and 9). From the proof of Lemma 1, we then have

$$\begin{aligned}
\frac{\partial \vartheta_a(\tau_a, \tau^*_a, \theta)}{\partial \tau_a} + \frac{\partial \vartheta^*_a(\tau_a, \tau^*_a)}{\partial \tau_a} &= \frac{1}{2}(\theta - 1)(p_{y_a} - f) - \tau_a - \frac{1}{2}D\tau^*_a = 0; \\
\frac{\partial \vartheta_a(\tau_a, \tau^*_a, \theta)}{\partial \tau^*_a} + \frac{\partial \vartheta^*_a(\tau_a, \tau^*_a)}{\partial \tau^*_a} &= -\frac{1}{2}D\tau_a - \tau^*_a = 0; \\
\frac{\partial \vartheta_b(\tau_b, \tau^*_b)}{\partial \tau^*_b} + \frac{\partial \vartheta^*_b(\tau_b, \tau^*_b)}{\partial \tau^*_b} &= -\tau^*_b - \frac{1}{2}D\tau_b = 0.
\end{aligned}$$

From the third first-order-condition we have $\tau^e_b = \tau^{*e}_b = 0$.

Solving the first two first-order-conditions simultaneously yields

$$\tau^e_a = \frac{2}{4 - D^2}(\theta - 1)(p_{y_a} - f); \quad \tau^{*e}_a = \frac{D}{D^2 - 4}(\theta - 1)(p_{y_a} - f). \tag{34}$$

Hence, for $\theta_L = 1$, we have $\tau^e_{aL} = \tau^{*e}_{aL} = 0$.

Using $p_{y_a} = \frac{1}{2}\tau_a + \frac{2A+f}{4-2D}$ (from lemma 1), evaluating it at $\tau_a = \tau^e_{aH}$, and substituting it into Eq.(34), together with $D \in (0, 1)$, $\theta_H < \bar{\theta} < 5 - D^2$, and $p_{y_a} - f = q^s_{y_a} > 0$, yields

$$\tau^{*e}_{aH} = -\frac{D}{2}\frac{(\theta_H - 1)(2Df - 3f + 2A)}{(2 - D)(5 - \theta_H - D^2)} < 0 < \tau^e_{aH} = \frac{(\theta_H - 1)(2Df + 2A - 3f)}{(2 - D)(5 - \theta_H - D^2)}.$$

□

Proposition 2. *Under a same-sector retaliation mechanism,*

(i) *the incentive-unconstrained joint political-welfare-maximizing import tariffs are as follows:*

$$\tau^S_b = \tau^{*S}_b = \tau^S_{aL} = \tau^{*S}_{aL} = 0 < \tau^{*S}_{aH} = \tau^S_{aH} = \frac{(\theta_H - 1)(2A + 2Df - 3f)}{(D - 2)(\theta_H - 4D - 9)}.$$

(ii) *the incentive-unconstrained joint political-welfare-maximizing import tariff in a high state is smaller than the politically efficient tariff, i.e.* $\tau^S_{aH} < \tau^e_{aH}$.

Proof. (*i*) Writing $\eta_S = \lambda V(\tau_{aH}, \tau^*_{aH}, \theta_H, \tau_b, \tau^*_b) + (1-\lambda)V(\tau_{aL}, \tau^*_{aL}, \theta_L, \tau_b, \tau^*_b) - E(V^{BN}(\theta))$ and $\eta^*_S = \lambda V^*(\tau_{aH}, \tau^*_{aH}, \tau_b, \tau^*_b) + (1-\lambda)V^*(\tau_{aL}, \tau^*_{aL}, \tau_b, \tau^*_b) - EV^{*BN}(\theta)$ and noting that $\zeta_S = (\lambda[V(\tau_{aH}, \tau^*_{aH}, \theta_H, \tau_b, \tau^*_b) - V^*(\tau_{aH}, \tau^*_{aH}, \tau_b, \tau^*_b)] + (1 -$

$\lambda)[V(\tau_{aL},\tau^*_{aL},\theta_L,\tau_b,\tau^*_b) - V^*(\tau_{aL},\tau^*_{aL},\tau_b,\tau^*_b)] + EV^{*BN}(\theta) - E(V^{BN}(\theta)))/2$, we have that $\eta^*_S + \zeta_S = \eta_S - \zeta_S$. The first-order-conditions for the sector a tariffs for the following maximization problem

$$\max_{\tau_{aH},\tau^*_{aH},\tau_{aL},\tau^*_{aL},\tau_b,\tau^*_b} [\lambda V(\tau_{aH},\tau^{*RRS}_{aH}(\tau^S_{aH}),\theta_H,\tau_b,\tau^*_b) + (1-\lambda)V(\tau_{aL},\tau^*_{aL},\theta_L,\tau_b,\tau^*_b) - E(V^{BN}(\theta)) - \zeta_S]$$
$$\times [\lambda V^*(\tau_{aH},\tau^{*RRS}_{aH}(\tau^S_{aH}),\tau_b,\tau^*_b) + (1-\lambda)V^*(\tau_{aL},\tau^*_{aL},\tau_b,\tau^*_b) - EV^{*BN}(\theta) + \zeta_S]$$

are then given as

$$\left[\frac{\partial[V(\tau_{aH},\tau^{*RRS}_{aH}(\tau^S_{aH}),\theta_H,\tau_b,\tau^*_b)}{\partial\tau_{aH}} + \frac{\partial[V^*(\tau_{aH},\tau^{*RRS}_{aH}(\tau^S_{aH}),\tau_b,\tau^*_b)}{\partial\tau_{aH}}\right]\lambda(\eta_S - \zeta_S) +$$
$$\left[\frac{\partial[V(\tau_{aH},\tau^{*RRS}_{aH}(\tau^S_{aH}),\theta_H,\tau_b,\tau^*_b)}{\partial\tau^*_{aH}}\frac{\partial\tau^{*RRS}_{aH}(\tau^S_{aH})}{\partial\tau^S_{aH}} + \frac{\partial[V^*(\tau_{aH},\tau^{*RRS}_{aH}(\tau^S_{aH}),\tau_b,\tau^*_b)}{\partial\tau^*_{aH}}\frac{\partial\tau^{*RRS}_{aH}(\tau^S_{aH})}{\partial\tau^S_{aH}}\right]\lambda(\eta_S - \zeta_S) = 0;$$
$$\left[\frac{\partial[V(\tau_{aH},\tau^*_{aH},\theta_L,\tau_b,\tau^*_b)}{\partial\tau_{aL}}) + \frac{\partial[V^*(\tau_{aH},\tau^*_{aH},\tau_b,\tau^*_b)}{\partial\tau_{aL}}\right](1-\lambda)(\eta_e - \zeta_e) = 0;$$
$$\left[\frac{\partial[V(\tau_{aH},\tau^*_{aH},\theta_L,\tau_b,\tau^*_b)}{\partial\tau^*_{aL}}) + \frac{\partial[V^*(\tau_{aH},\tau^*_{aH},\tau_b,\tau^*_b)}{\partial\tau^*_{aL}}\right](1-\lambda)(\eta_S - \zeta_S) = 0.$$

subject to constraints (12, 13). Hence, the solution to the above problem is the same as the solution to the incentive-unconstrained maximization of expected joint political welfare (16).The results for sector b are similar and because there is complete information in sector b the first-order-conditions are the same as those derived in proposition 1. Hence, $\tau^S_b = \tau^{*S}_b = 0$.

Using Lemma 1 the full reciprocity condition, equation (10), can be rewritten as $(\frac{1}{2}\tau^*_{aL} + \Psi)(\frac{f}{2} - \tau^{*FRS}_{aH} - \frac{1}{2}D\tau_{aH} - (\frac{f}{2} - \tau^*_{aL} - \frac{1}{2}D\tau_{aL}))= (\frac{1}{2}\tau_{aL} + \Psi)(-\tau_{aH} - \frac{1}{2}D\tau^{*FRS}_{aH} + \tau_{aL} + \frac{1}{2}D\tau^*_{aL}))$. From the proof to Lemma 1 we know that $\tau^{*R}_{aH}(\tau^S_{aH}) = \frac{f-D\tau^S_{aH}}{6} = argmax\{V^*(\tau_{aH},\tau^{*R}_{aH}(\tau^S_{aH}),\tau_b,\tau^*_b)\}$. Foreign's reciprocal response is then $\tau^{*RRS}_{aH} = min\{\tau^{*FRS}_{aH}, \frac{f-D\tau_{aH}}{6}\}$.

For sector a we start by assuming that the Foreign takes the full allowed reciprocity, so that $\tau^{*RRS}_{aH} = \tau^{*FRS}_{aH} \leq \frac{f-D\tau_{aH}}{6}$, and then we confirm that it is the case.

Given equations (32) and (33), the solutions to the the second and third first-order-conditions must satisfy:

$$\vartheta_{a1}(\tau^S_{aL},\tau^{*S}_{aL},\theta_L) + \vartheta^*_{a1}(\tau^S_{aL},\tau^{*S}_{aL}) = -\tau^S_{aL} - \frac{1}{2}D\tau^{*S}_{aL} = 0,$$

$$\vartheta_{a2}(\tau^S_{aL},\tau^{*S}_{aL},\theta_L) + \vartheta^*_{a2}(\tau^S_{aL},\tau^{*S}_{aL}) = -\frac{1}{2}D\tau^S_{aL} - \tau^{*S}_{aL} = 0,$$

which yields: $\tau^S_{aL} = \tau^{*S}_{aL} = 0$. Hence, the full reciprocity condition is reduced to $\Psi(-\tau^{*FRS}_{aH} - \frac{1}{2}D\tau_{aH})= \Psi(-\tau_{aH} - \frac{1}{2}D\tau^{*FRS}_{aH})$ which yields $\tau^{*FRS}_{aH} = \tau^S_{aH}$. Hence, if $\tau^{*RRS}_{aH} = \tau^{*FRS}_{aH}$, then $\frac{\partial\tau^{*RRS}_{aH}(\tau^S_{aH})}{\partial\tau^S_{aH}} = 1$. The first first-order-condition can then be written as

$$\vartheta_{a1}(\tau_{aH}^S, \tau_{aH}^{*S}, \theta_H) + \vartheta_{a1}^*(\tau_{aH}^S, \tau_{aH}^{*S}) + \left[\vartheta_{a2}(\tau_{aH}^S, \tau_{aH}^{*S}, \theta_H) + \vartheta_{a2}^*(\tau_{aH}^S, \tau_{aH}^{*S})\right] \frac{\partial \tau_{aH}^{*RRS}(\tau_{aH}^S)}{\partial \tau_{aH}^S}$$
$$= \frac{1}{2}(\theta_H - 1)\frac{p_{y_a} - f}{2} - \tau_{aH}^S - \frac{1}{2}D\tau_{aH}^S - \frac{1}{2}M_a^* - \frac{1}{2}D\tau_{aH}^S + \frac{1}{2}M_a^* - \tau_{aH}^S = 0,$$

which yields:

$$\tau_{aH}^S = \frac{1}{4+2D}(\theta_H - 1)(p_{y_a} - f). \tag{35}$$

Using $p_{y_a} = \frac{1}{2}\tau_a + \frac{2A+f}{4-2D}$ (from Lemma 1) evaluated at $\tau_a = \tau_{aH}^S$, along with $A > 2f$, $1 < \theta_H < \bar{\theta} < 9+4D$, $D \in (0,1)$ and equation (35), yields

$$\tau_{aH}^S = \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(2-D)(9+4D-\theta_H)} > 0.$$

For the reciprocity constraint to bind requires that $\tau_{aH}^S = \frac{(\theta_H-1)(2Df-3f+2A)}{(2-D)(9+4D-\theta_H)} \leq \frac{f - D\tau_{aH}^S}{6}$ or $\tau_{aH}^S \leq \frac{f}{6+D}$, which is satisfied as long as $\theta \leq \frac{6A+AD+4Df-D^2f}{6A+AD-8f+4Df+D^2f}$ which holds because $\frac{6A+AD+4Df-D^2f}{6A+AD-8f+4Df+D^2f} > \frac{12A+3Df}{12A+(-16+11D)f} = \bar{\theta}^{FR}(A,f,D,\gamma=1)$ which holds because $A > 2f$ and $D \in [0,1]$. Hence, the condition $\theta \leq \bar{\theta}$ and the result that $\tau_{aL}^S = \tau_{aL}^{*S}$ shows that the reciprocity constraint binds.

(ii) Comparing $\tau_{aH}^e = \frac{(\theta_H-1)(2Df-3f+2A)}{(2-D)(5-\theta_H-D^2)}$ (from Propositions 1) and $\tau_{aH}^S = \frac{(\theta_H-1)(2Df-3f+2A)}{(2-D)(9+4D-\theta_H)}$ (from Proposition 2(i)), given that $D-2<0$, $2Df-3f+2A>0$ and $\theta_H > 1$, all we need to show is that

$$-4D + \theta_H - 9 < D^2 + \theta_H - 5 < 0.$$

which is true since $\theta_H < \bar{\theta} < 5 - D^2 < 9 + 4D$. □

Proposition 3. *Under a same-sector retaliation mechanism with incentive-unconstrained solutions, the incentive compatibility conditions (14) and (15) are slack.*

Proof. To prove that the incentive compatibility conditions are slack, we must show that equations (14) and (15) hold as strict inequalities. From proposition 1 we have that $\frac{\partial \vartheta_a(\tau_a,\tau_a,\theta)}{\partial \tau_a} = \frac{1}{2}(\theta-1)q_{y_a}^s(p_{y_a},p_{x_a}) - \tau_a - \frac{1}{2}D\tau_a$. When $\theta = \theta_L = 1$ this derivative is negative so that $\vartheta_a(\tau_a,\tau_a,\theta)$ is monotonically decreasing in τ_a. Given that $\tau_{aL}^S < \tau_{aH}^S$ (from Proposition 2), equation (14) holds as a strict inequality. To show that equation (15) is slack we show that $\hat{\tau_{aH}} = \underset{\tau_a}{\operatorname{argmax}} \quad \vartheta_a(\tau_a,\tau_a,\theta_H) > \tau_{aH}^S$ which along with the fact that $\hat{\tau_{aL}} = \underset{\tau_a}{\operatorname{argmax}} \quad \vartheta_a(\tau_a,\tau_a,\theta_L) = \tau_{aL}^S = 0 < \tau_{aH}^S$ establishes that $\vartheta_a(\tau_a,\tau_a,\theta_H)$ is monotonically increasing on the interval $[\tau_{aL}^S, \tau_{aH}^S]$.

From equations (32) and (33) , we know that $\hat{\tau_{aH}}$ and τ_{aH}^S must satisfy:

$$\frac{1}{2}[\theta_H q_y^s(p_y) - q_y^d(p_y,p_x)] + M_a - \hat{\tau_{aH}} - \frac{1}{2}M_a^* - \frac{1}{2}D\hat{\tau_{aH}} = 0;$$
$$\frac{1}{2}[\theta_H q_y^s(p_y) - q_y^d(p_y,p_x)] + M_a - \tau_{aH}^S - \frac{1}{2}M_a^* - \frac{1}{2}D\tau_{aH}^S - \frac{1}{2}M_a - \frac{1}{2}D\tau_{aH}^S + \frac{1}{2}M_a^* - \tau_{aH}^S = 0.$$

Let $G(\tau) = \frac{1}{2}[\theta_H q_y^s(p_y) - q_y^d(p_y, p_x)] + M_a - \tau - \frac{1}{2}M_a^* - \frac{1}{2}D\tau$. Given that $G(\hat{\tau_{aH}}) = 0, G(\tau_{aH}^S) > 0$ and $\frac{\partial G(\tau)}{\partial \tau} < 0$, we must have $\hat{\tau_{aH}} > \tau_{aH}^S$. Thus, condition (15) is slack. □

Proposition 4.

(i) *The incentive-unconstrained joint political-welfare-maximizing tariffs under a cross-sector retaliation mechanism are as follows:*

$$\tau_{bL}^C = \tau_{bL}^{*C} = \tau_{aL}^C = \tau_{aL}^{*C} = \tau_{bH}^C = \tau_{aH}^{*C} = 0 < \tau_{aH}^C = \tau_{bH}^{*C} = \frac{(\theta_H - 1)(2A + 2Df - 3f)}{(D-2)(\theta_H - 9)}.$$

(ii) *The incentive-unconstrained joint political-welfare-maximizing tariff in a high state under a cross-sector retaliation mechanism is greater than under a same-sector retaliation mechanism while smaller than the politically efficient tariff:* $\tau_{aH}^S < \tau_{aH}^C < \tau_{aH}^E$.

Proof. (i) Since the side payment equalizes the gains from cooperation and because tariffs are chosen after Home announces the state it is straightforward to verify, as in proposition 2 that the solution to equation (17) is equivalent to the solution to $\max\limits_{\tau_{aH}, \tau_{bH}^*, \tau_{aL}^*, \tau_{bL}} \Omega(\theta_H)$ subject to the constraints given by equations (18, and 20) where we inserted the constraint $\tau_{aH}^* = \tau_{aL}^*, \tau_{bH} = \tau_{bL}$ into the objective problem.

The first-order conditions from the above maximization problem can be written as

$$\vartheta_{a1}(\tau_{aL}, \tau_{aL}^*, \theta_L) + \vartheta_{a1}^*(\tau_{aL}, \tau_{aL}^*) = \vartheta_{a2}(\tau_{aL}, \tau_{aL}^*, \theta_L) + \vartheta_{a2}^*(\tau_{aL}, \tau_{aL}^*) = 0;$$

$$\vartheta_{b1}(\tau_{bL}, \tau_{bL}^*) + \vartheta_{b1}^*(\tau_{bL}, \tau_{bL}^*) = \vartheta_{b2}(\tau_{bL}, \tau_{bL}^*) + \vartheta_{b2}^*(\tau_{bL}, \tau_{bL}^*) = 0;$$

$$\vartheta_{a2}(\tau_{aH}, \tau_{aL}^*, \theta_H) + \vartheta_{a2}^*(\tau_{aH}, \tau_{aL}^*) = \vartheta_{b1}(\tau_{bL}, \tau_{bH}^*) + \vartheta_{b1}^*(\tau_{bL}, \tau_{bH}^*) = 0;$$

$$\vartheta_{a1}(\tau_{aH}, \tau_{aL}^*, \theta_H) + \vartheta_{a1}^*(\tau_{aH}, \tau_{aL}^*) = \vartheta_{b2}(\tau_{bL}, \tau_{bH}^*) + \vartheta_{b2}^*(\tau_{bL}, \tau_{bH}^*) = 0.$$

From the first two first-order-conditions we have that $\tau_{aL}^C = \tau_{aL}^{*C} = 0$. From the third and fourth first-order-conditions we have that $\tau_{bL}^C = \tau_{bL}^{*C} = 0$. From the fifth and sixth first-order-conditions we have that $\tau_{aL}^{*C} < 0$ and that $\tau_{bL}^C < 0$. Given the non-negativity condition we must then have $\tau_{aL}^{*C} = \tau_{bL}^C = 0$. Substituting $\tau_{aL}^C = \tau_{bL}^{*C}$ into the reciprocity constraint yields $\tau_{bH}^{*FRC} = \tau_{aH}^*$ and then substituting $\tau_{bL}^C = 0$ into $\tau_{bH}^{*R}(\tau_{bL}^C) = \frac{f}{6}$ yields $\tau_{bH}^{*RRC} = min\{\tau_{aH}^{*C}, \frac{f}{6}\}$. If $\tau_{aH}^{*C} \leq \frac{f}{6}$ we can then rewrite the seventh and eighth first order conditions as $\vartheta_{a1}(\tau_{aH}, 0, \theta_H) + \vartheta_{a1}^*(\tau_{aH}, 0) + \vartheta_{b2}(0, \tau_{aH}) + \vartheta_{b2}^*(0, \tau_{aH}) = 0$ which yields $\tau_{aH}^C = \frac{(\theta_H - 1)(2Df + 2A - 3f)}{(2-D)(9-\theta_H)} > 0$. It is straightforward to verify that $\tau_{aH}^C < \frac{f}{6}$ as long as $\theta_H < \frac{12A + 3Df}{12A + (-16 + 11D)f} = \bar{\theta}^{FR}(A, f, D, \gamma = 1)$.

(ii) To show that $\tau_{aH}^S < \tau_{aH}^C < \tau_{aH}^E$, we first note that the numerators are the same, that $2Df + 2A - 3f > 0$, that $D - 2 < 0$ and that $\theta_H > 1$, Hence, we only need to show that

$$-4D + \theta_H - 9 < \theta_H - 9 < D^2 + \theta_H - 9 < 0,$$

which is true because $D \in (0,1)$ and $\theta_H < 9 - D^2 < \bar{\theta}$. $\square$

Proposition 5. *Under a cross-sector retaliation mechanism with incentive-unconstrained solutions the incentive compatibility conditions (21) and (22) are slack.*

Proof. Substituting $\tau^C_{bL} = \tau^{*C}_{bL} = \tau^C_{aL} = \tau^{*C}_{aL} = \tau^C_{bH} = \tau^{*C}_{aH} = 0$ and $\tau^C_{aH} = \tau^{*C}_{bH}$ into equations (21) and (22) and rearranging we have to show that $\vartheta_a(0,0,\theta_L) - \vartheta_a(\tau^C_{aH},0,\theta_L) > \vartheta_b(0,\tau^C_{aH}) - \vartheta_b(0,0)$ and that $\vartheta_a(\tau^C_{aH},0,\theta_H) - \vartheta_a(0,0,\theta_H) > \vartheta_b(0,0) - \vartheta_b(0,\tau^C_{aH})$.

Given that $(0,0) = \underset{\{\tau_a,\tau^*_a\}}{\text{argmax}} \ \{\vartheta_a(\tau_a,\tau^*_a,\theta_L) + \vartheta^*_a(\tau_a,\tau^*_a)\}$ and $\tau^C_{aH} > 0$, we have $\vartheta_a(0,0,\theta_L) + \vartheta^*_a(0,0) > \vartheta_a(\tau^C_{aH},0,\theta_L) + \vartheta^*_a(\tau^C_{aH},0)$, which can be rearranged to yield $\vartheta_a(0,0,\theta_L) - \vartheta_a(\tau^C_{aH},0,\theta_L) > \vartheta^*_a(\tau^C_{aH},0) - \vartheta^*_a(0,0)$.

Given that when $\theta = \theta_L$, home and foreign are symmetric and sectors a and b are identical, implies that

$$\vartheta^*_a(\tau^C_{aH},0) - \vartheta^*_a(0,0) = \vartheta_a(0,\tau^C_{aH},\theta_L) - \vartheta_a(0,0,\theta_L) = \vartheta_b(0,\tau^C_{aH}) - \vartheta_b(0,0)$$

which in turn shows that $\vartheta_a(0,0,\theta_L) - \vartheta_a(\tau^C_{aH},0,\theta_L) > \vartheta_b(0,\tau^C_{aH}) - \vartheta_b(0,0)$ completing the proof that condition (21) is slack.

Now we show that condition (22) is slack. Using the above argument we know that:

$$\vartheta^*_a(0,0) - \vartheta^*_a(\tau^C_{aH},0) = \vartheta_b(0,0) - \vartheta_b(0,\tau^C_{aH}).$$

Therefore,

$$\begin{aligned}
&\vartheta_a(\tau^C_{aH},0,\theta_H) - \vartheta_a(0,0,\theta_H) - \Big[\vartheta_b(0,0) - \vartheta_b(0,\tau^C_{aH})\Big] \\
=&\vartheta_a(\tau^C_{aH},0,\theta_H) - \vartheta_a(0,0,\theta_H) - \Big[\vartheta^*_a(0,0) - \vartheta^*_a(\tau^C_{aH},0)\Big] \\
=&\vartheta_a(\tau^C_{aH},0,\theta_H) + \vartheta^*_a(\tau^C_{aH},0) - [\vartheta_a(0,0,\theta_H) + \vartheta^*_a(0,0)] > 0.
\end{aligned}$$

To see that this expression is strictly positive note that $\vartheta_a(\tau_a,0,\theta_H) + \vartheta^*_a(\tau_a,0)$ is strictly increasing in τ_a for $\tau_a \in [0,\tau^{\hat{C}}_{aH})$, where $\tau^{\hat{C}}_{aH} = \underset{\{\tau\}}{\text{argmax}} \ \ \vartheta_a(\tau,0,\theta_H) + \vartheta^*_a(\tau,0) = \frac{(\theta_H-1)(2A+f)}{(2-D)(5-\theta_H)} > \frac{(\theta_H-1)(2Df+2A-3f)}{(2-D)(9-\theta_H)} = \tau^C_{aH}$. Hence, equation (22) holds as a strict inequality . $\square$

Proposition 6. *The joint political-welfare-maximizing incentive-compatible negotiated import tariffs under a cross-sector retaliation mechanism generate greater joint political welfare than do the joint political-welfare-maximizing incentive-compatible negotiated tariffs under a same-sector retaliation mechanism.*

Proof. Let $E\Omega^S(\theta)$ and $E\Omega^C(\theta)$ denote the expected joint welfare generated by the negotiated import tariffs under a same-sector and cross-sector retaliation mechanism, respectively. Substituting for the negotiated tariffs derived in propositions 2 and 4 and noting that both mechanisms are the same in the low state yields:

$$E\Omega^S(\theta) - E\Omega^C(\theta) = \lambda[\vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S) + \vartheta_b(0,0) + \vartheta_b^*(0,0)$$
$$- \vartheta_a(\tau_{aH}^C, 0, \theta_H) - \vartheta_a^*(\tau_{aH}^C, 0) - \vartheta_b(0, \tau_{aH}^C) - \vartheta_b^*(0, \tau_{aH}^C)].$$

Since Home and Foreign are symmetric, we have $\vartheta_b(0,0) = \vartheta_b^*(0,0)$, $\vartheta_a^*(\tau_{aH}^C, 0) = \vartheta_a(0, \tau_{aH}^C, \theta_L) = \vartheta_b(0, \tau_{aH}^C)$ and $\vartheta_b^*(0, \tau_{aH}^C) = \vartheta_b(\tau_{aH}^C, 0)$. Therefore,

$$E\Omega^S(\theta) - E\Omega^C(\theta) = \lambda[\vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S) + 2\vartheta_b(0,0)$$
$$- \vartheta_a(\tau_{aH}^C, 0, \theta_H) - 2\vartheta_b(0, \tau_{aH}^C) - \vartheta_b(\tau_{aH}^C, 0)].$$

Together with equations (31), (23) and (24), we have

$$E\Omega^S(\theta) - E\Omega^C(\theta) = \frac{-D\lambda(\theta_H - 1)^2(2A - 3f + 2Df)^2}{2(2-D)^2(9-\theta_H)(9-\theta_H+4D)} < 0$$

since $0 < D < 1$, $\theta_H < \bar{\theta} < 9$, $0 < \lambda < 1$. □

Proposition 7.

(i) *The joint political-welfare-maximizing incentive-compatible import tariffs under a cross-sector retaliation mechanism generate less joint social welfare than do those under a same-sector retaliation mechanism.*

(ii) *If tariffs are the same under both mechanisms, then joint social welfare is greater under a cross-sector retaliation mechanism than under a same-sector retaliation mechanism.*

Proof. (i) and (ii). Let $E\Omega^{US}(\theta)$ and $E\Omega^{UC}(\theta)$ denote the expected social welfare generated by the same- and cross-sector mechanisms, respectively. First, we substitute for the negotiated tariffs derived in propositions 2 and 4. Next, we note that both mechanisms are the same in the low state yields, that Home and Foreign are symmetric in sector *b*, and that the countries are symmetric in either state when considering social welfare. We then have:

$$\begin{aligned} E\Omega^{US}(\theta) - E\Omega^{UC}(\theta) &= \lambda[\vartheta_a(\tau_{aH}^S, \tau_{aH}^S) + \vartheta_a(\tau_{aH}^S, \tau_{aH}^S) + 2\vartheta_b(0,0) \\ &\quad - \vartheta_a(\tau_{aH}^C, 0) - 2\vartheta_b(0, \tau_{aH}^C) - \vartheta_b(\tau_{aH}^C, 0)] \\ &= \lambda\frac{2(\tau_{aH}^C)^2 - (2+D)(\tau_{aH}^S)^2}{2}. \end{aligned}$$

To prove part (ii) note that if $\tau_{aH}^C = \tau_{aH}^S$ (so that tariffs were the same in both mechanisms), then the above expression would be negative and social welfare would be greater under the cross-sector retaliation mechanism. For part (i) using equations (31), (23) and (24) yields:

$$E\Omega^{US}(\theta) - E\Omega^{UC}(\theta) = \frac{\lambda D(2A - 3f + 2Df)^2(\theta_H - 1)^2(63 + 32D + 2\theta_H - \theta_H^2)}{2(D-2)^2(\theta_H - 9)^2(\theta_H - 9 - 4D)^2} > 0$$

□

Proposition 8 *(i) If allowed to choose the sector of retaliation after Home sets its high-state tariff, then Foreign will retaliate cross sector. (ii) Foreign political and social welfare are both greater under the same-sector retaliation mechanism.*

Proof. (i) From the proof of Proposition 7(ii) we know that for any given Home tariff, $\bar{\tau}_{aH}$ the difference between same- and cross-sector retaliation welfare for Foreign is:

$$\lambda[\vartheta_a^*(\bar{\tau}_{aH}, \bar{\tau}_{aH}) + \vartheta_b^*(0,0) - \vartheta_a^*(\bar{\tau}_{aH}, 0) - \vartheta_b^*(0, \bar{\tau}_{aH})] = \lambda\frac{2(\bar{\tau}_{aH})^2 - (2+D)(\bar{\tau}_{aH})^2}{4} < 0.$$

Hence, Foreign would choose to cross-retaliate.

(ii) From the proof of Proposition 7(i) we know that ex-ante the difference in Foreign political and social welfare is

$$\lambda[\vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S) + \vartheta_b^*(0,0) - \vartheta_a^*(\tau_{aH}^C, 0) - \vartheta_b^*(0, \tau_{aH}^C) = \lambda\frac{2(\tau_{aH}^C)^2 - (2+D)(\tau_{aH}^S)^2}{2}$$

$$= \frac{\lambda D(2A - 3f + 2Df)^2(\theta - 1)^2(63 + 32D + 2\theta_H - \theta_H^2)}{2(D-2)^2(\theta_H - 9)^2(\theta_H - 9 - 4D)^2} > 0$$

□

Proposition 9. *If the goods or sectors available for retaliation in agreement a have extent of substitutability D with goods in the original Home high-tariff sector, then Foreign's preference for, and the joint political-welfare benefit from, cross-agreement retaliation is increasing in this extent of substitutability parameter D.*

Proof. From the proof of Proposition 8, we have that for a given high-state tariff, denoted as $\bar{\tau}_{aH}$, the difference between Foreign's political welfare from cross- and same-agreement retaliation is given as$V^*(\bar{\tau}_{aH}, 0, 0, \bar{\tau}_{aH}) - V^*(\bar{\tau}_{aH}, \bar{\tau}_{aH}, 0, 0) = \frac{D(\bar{\tau}_{aH})^2}{4}$ which is increasing in D. From the proof of Proposition 6 we have that $\frac{D\lambda(\theta_H-1)^2(2A-3f+2Df)^2}{2(2-D)^2(9-\theta_H)(9-\theta_H+4D)} > 0$. Taking the derivative of this expression with respect to the extent of substitutability yields $\frac{\partial[E\Omega^C(\theta)-E\Omega^S(\theta)]}{\partial D} = \frac{D\lambda(\theta_H-1)^2(2A-3f+2Df)(2A[18+9D+8D^2-(2+D)\theta]-f[54-6\theta+9D\theta-81+2D^2(5-\theta)])}{2(2-D)^3(9-\theta_H)(9-\theta_H+4D)^2} > 0$ since $0 < D < 1$, $\theta_H < \bar{\theta} < 3$, $A > 2f$, and $\lambda > 0$. □

Proposition 13 *If there are welfare weights $\chi_a \in [1, \theta_H)$ and $\chi_b \in [1, \theta_H)$ on numeraire consumption provided by profits in Home's export industries, and if the probability of retaliation is the same for either mechanism ($\gamma^C =$*

$\gamma^S = \gamma$), then an increase in χ_a (χ_b) increases (reduces) the joint political-welfare advantage of cross-sector over same-sector retaliation. An increase in χ_a (χ_b) increases (reduces) the joint social-welfare advantage of same-sector over cross-sector retaliation.

Proof.

$$\frac{\partial[E\Omega^S(\gamma,\theta,\chi_a,\chi_b) - E\Omega^C(\gamma,\theta,\chi_a,\chi_b)]}{\partial\chi_b} =$$
$$\frac{\lambda\gamma[(2A-3f+2Df)(1-\theta_H)+\gamma(2A+f)(\chi_b-1)][A(6\theta_H+2\gamma\chi_b-22-18\gamma)+f(\gamma\chi_b-7-9\gamma-\theta_H+2D(\theta_H-1)]}{8(D-2)^2(\theta_H-5+\gamma(\chi_b-5))^2} > 0$$

$$\frac{\partial[E\Omega^S(\gamma,\theta,\chi_a,\chi_b) - E\Omega^C(\gamma,\theta,\chi_a,\chi_b)]}{\partial\chi_a} =$$
$$\frac{\lambda\gamma[(2A-3f+2Df)(1-\theta_H)+\gamma(2A+f)(\chi_a-1)][A(22+18\gamma+16D\gamma-6\theta_H-2\gamma\chi_a)+f(7+9\gamma+\theta_H-\gamma\chi_a-2D(\theta_H-1)]}{8(D-2)^2(\theta_H-5+\gamma(\chi_a-5-4D))^2} < 0$$

$$\frac{\partial[E\Omega^{US}(\gamma,\theta,\chi_a,\chi_b) - E\Omega^{UC}(\gamma,\theta,\chi_a,\chi_b)]}{\partial\chi_b} =$$
$$\frac{2\lambda\gamma(1+\gamma)[(2A-3f+2Df)(1-\theta_H)+\gamma(2A+f)(\chi_b-1)][A(6+4\gamma-2\theta_H)+f(1+D+2\gamma+\theta_H(1-D)]}{8(D-2)^2(5-\theta_H-\gamma(\chi_b-5))^3} < 0$$

$$\frac{\partial[E\Omega^{US}(\gamma,\theta,\chi_a,\chi_b) - E\Omega^{UC}(\gamma,\theta,\chi_a,\chi_b)]}{\partial\chi_a} =$$
$$\frac{-2\lambda\gamma(1+\gamma+D\gamma)[(2A-3f+2Df)(1-\theta_H)+\gamma(2A+f)(\chi_a-1)][A(6+4(1+D)\gamma-2\theta_H)+f(1+D+2\gamma(1+D)+\theta_H(1-D)]}{8(D-2)^2(5-\theta_H-\gamma(\chi_a-5-4D))^3} > 0$$

where we use $0 < \gamma < 1$, $0 < D < 1$, $1 \leq \chi_a < \theta_H < \bar{\theta} < 3$, $1 \leq \chi_b < \theta_H$,$A > 2f$, and $\lambda > 0$. The denominator of all four derivatives are positive. The first square-bracketed term in each numerator is negative. The second square-bracketed term in the first derivative is negative and in all the others they are positive. □